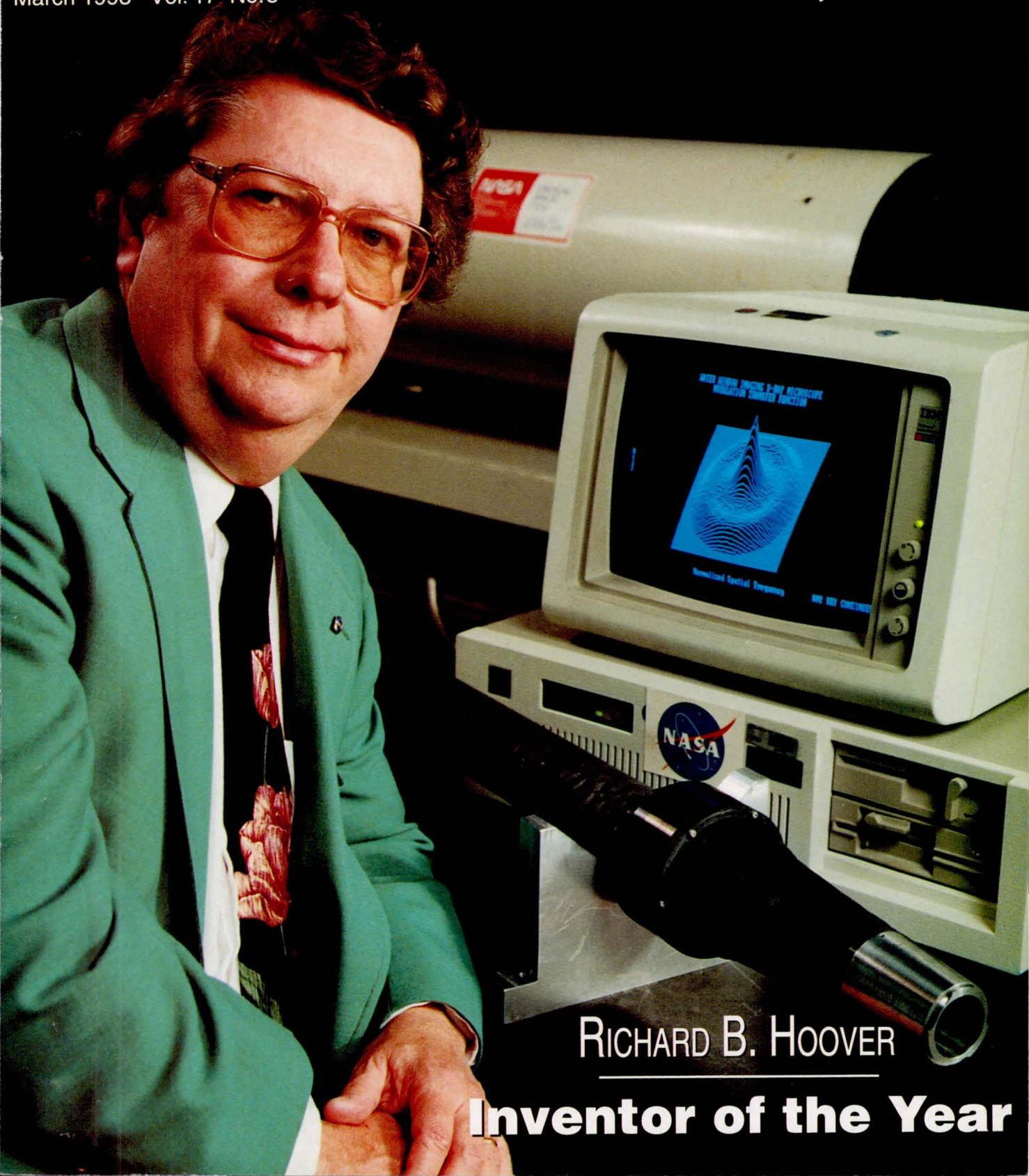


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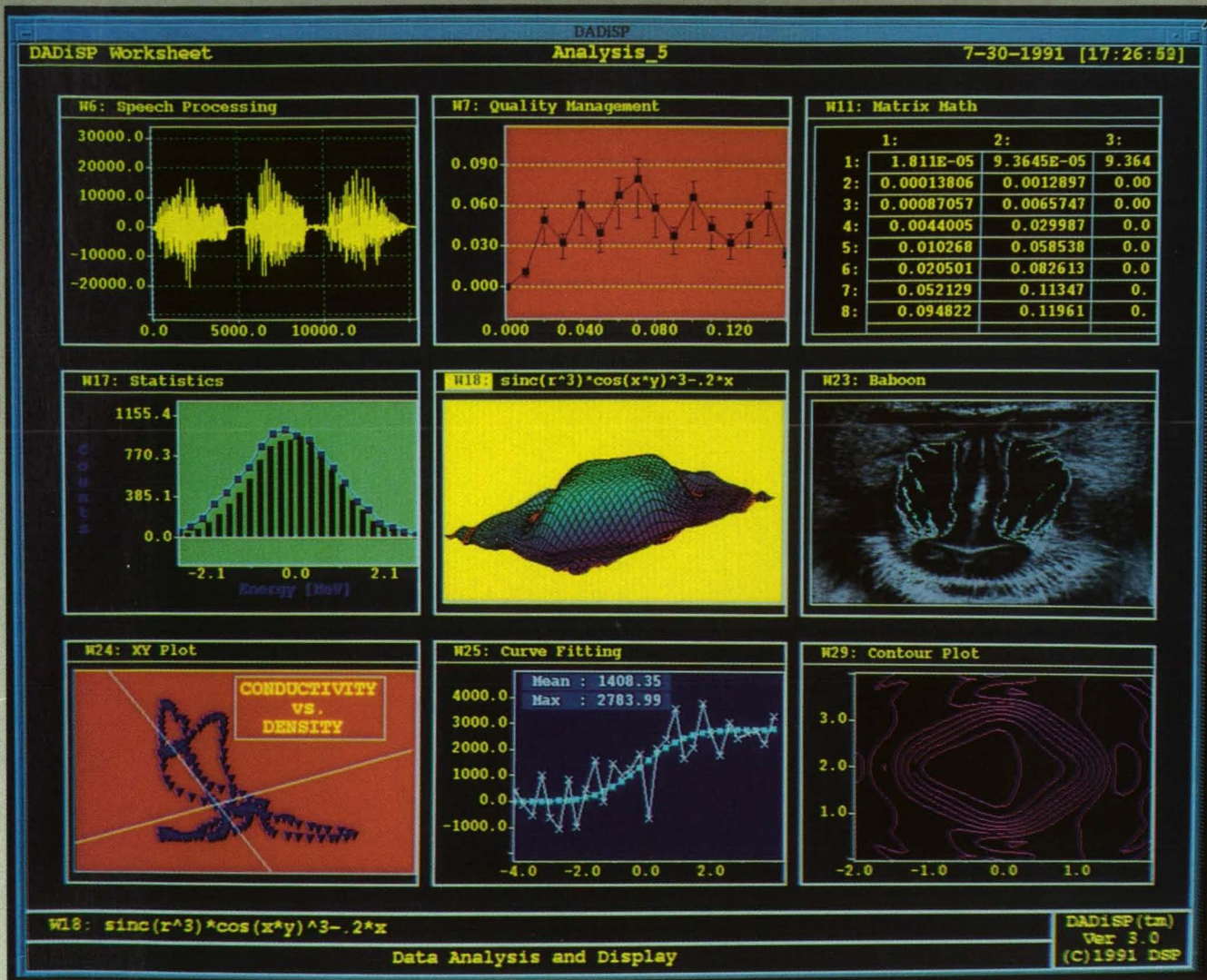
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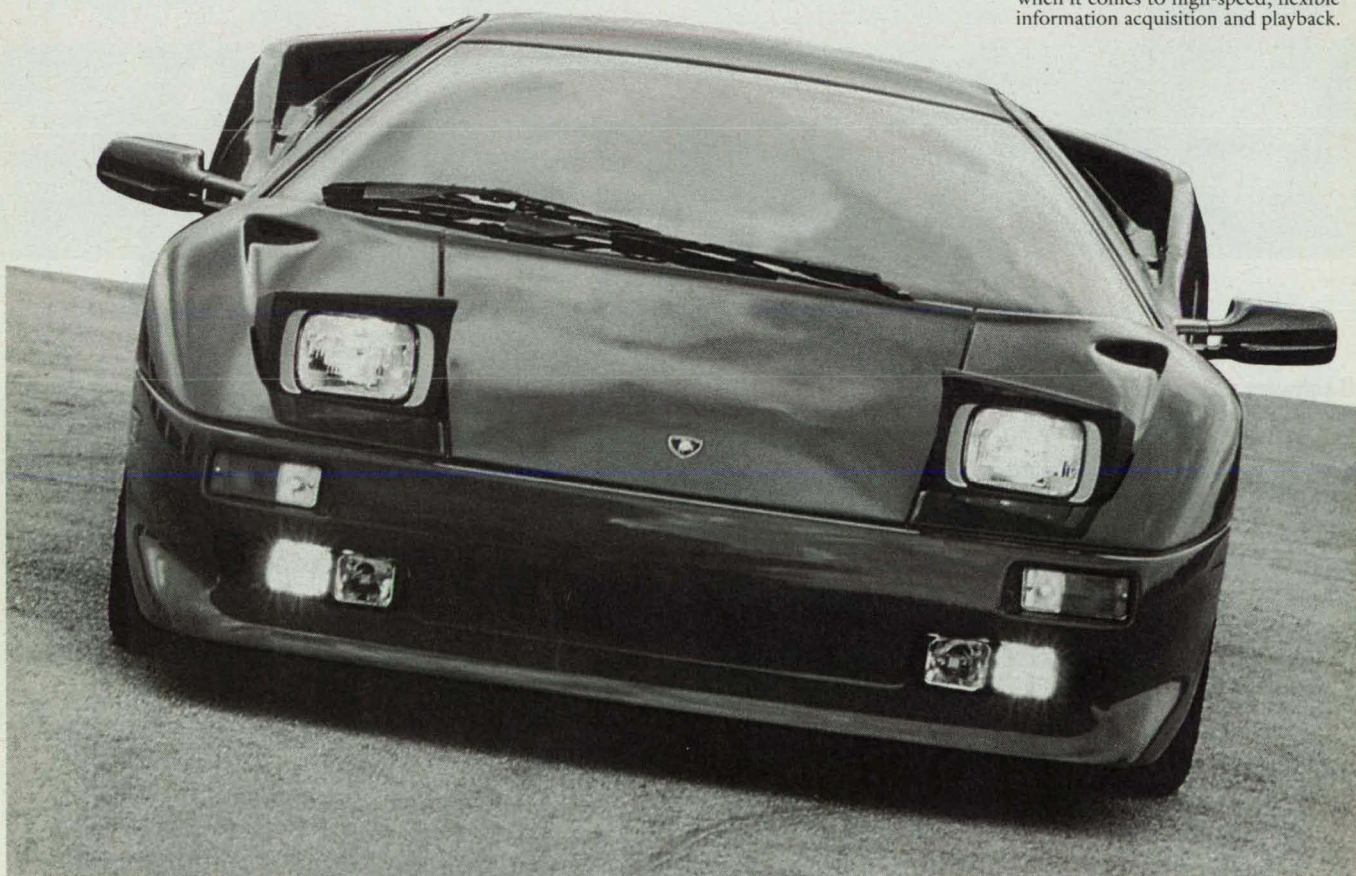
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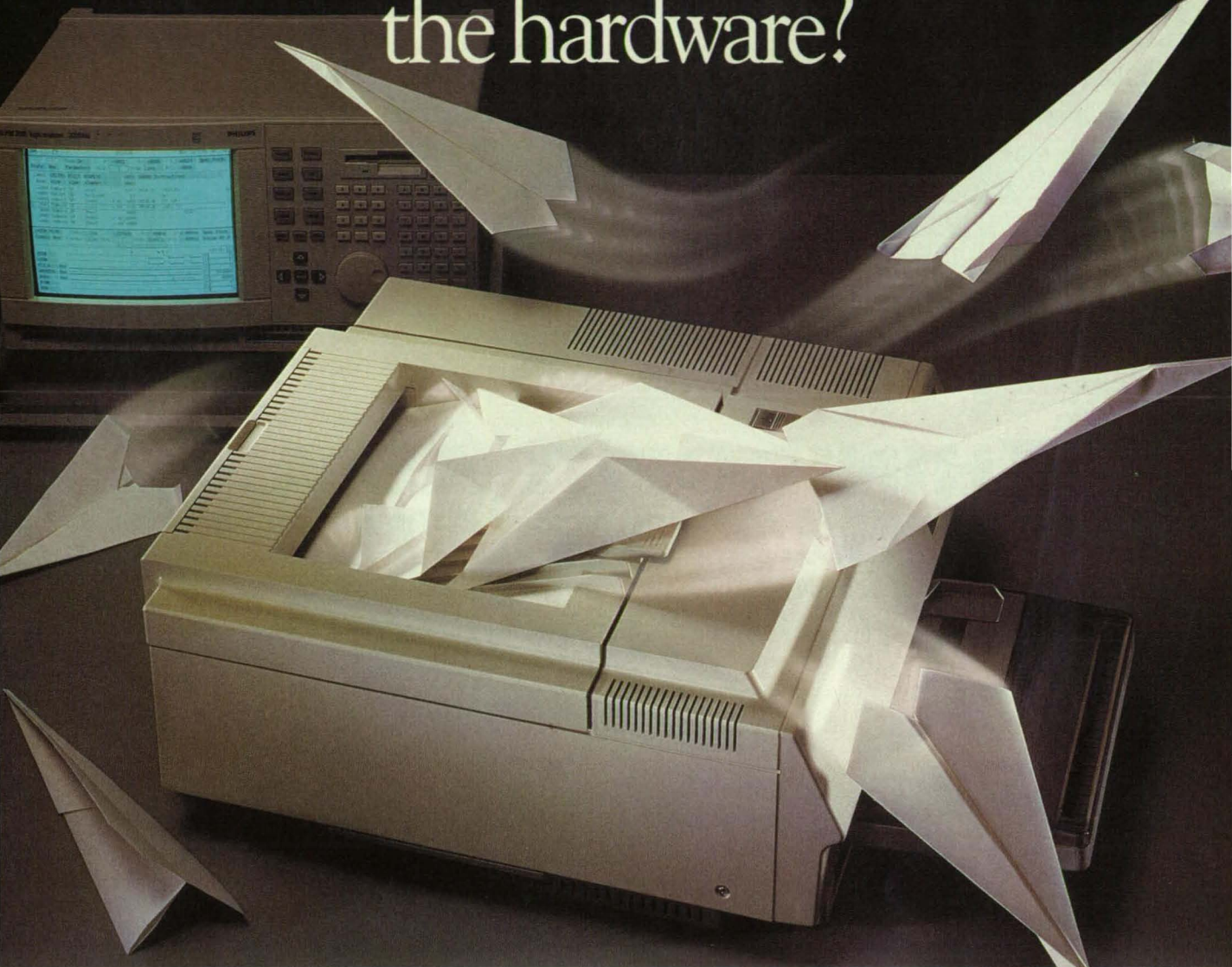


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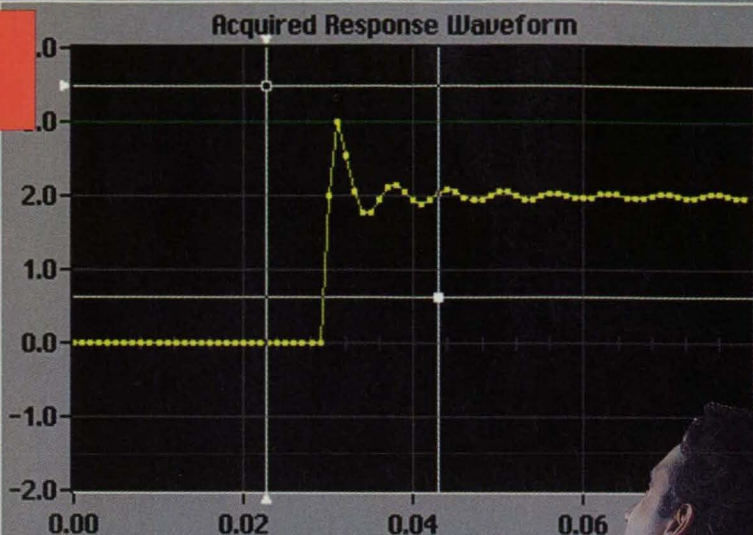
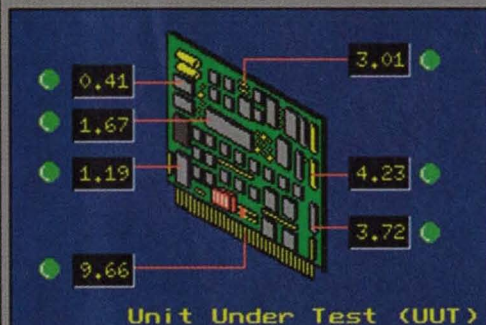
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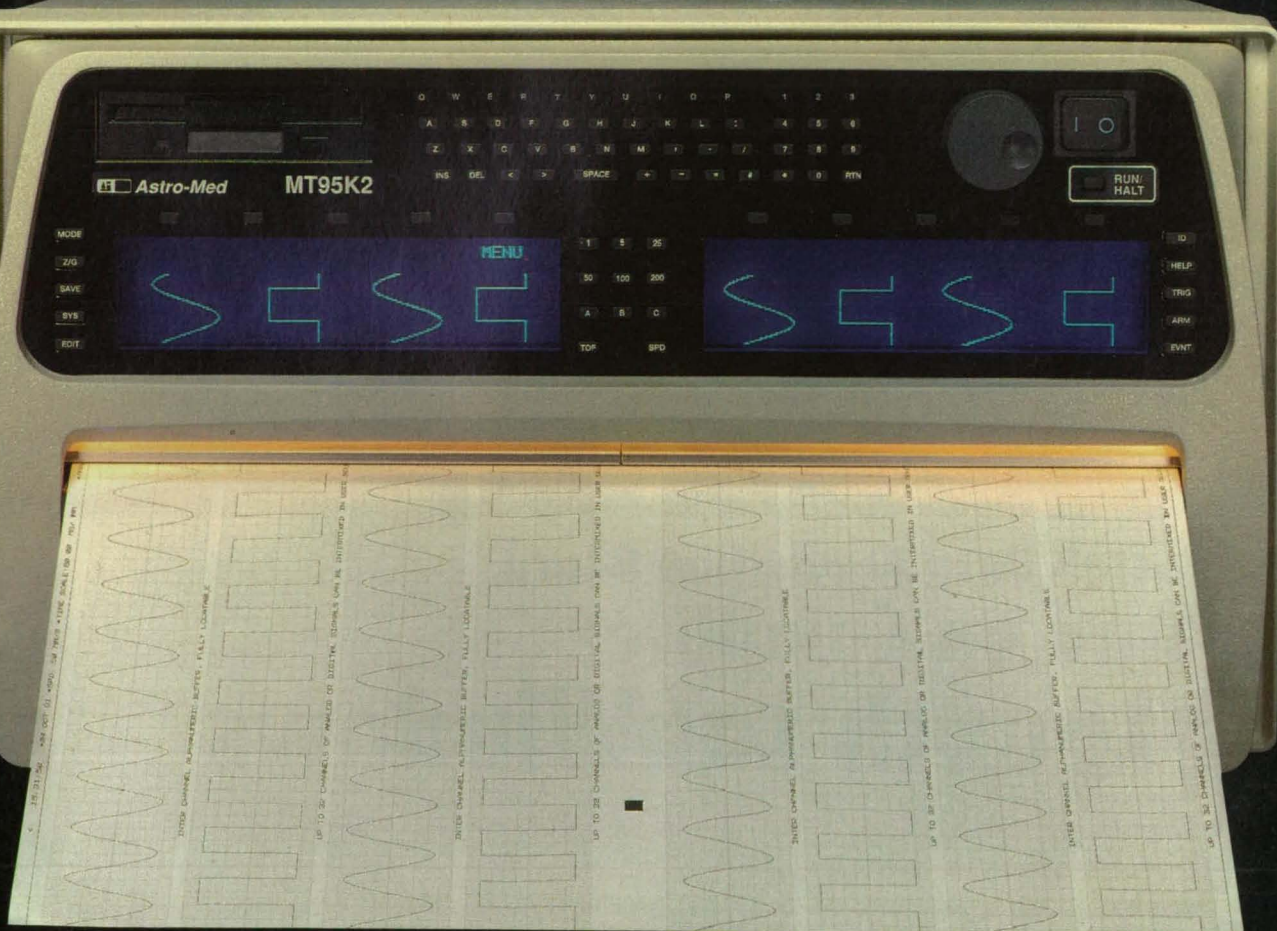
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Why ONE OF AMERICA'S MOST THOUGHT-PROVOKING ENGINEERS NOW USES THE DESIGN TOOL THAT THINKS.

❖ Two years after the Voyager completed its record-shattering around-the-world flight, you could still find its designer, Burt Rutan, working at a drafting table with pencil and paper.

Hardware wasn't the problem. He had computers. His company could buy any design system worth owning. What kept Burt grounded was software. CAD so clumsy, it squashed creativity. Or so weak, it simply couldn't do his job.

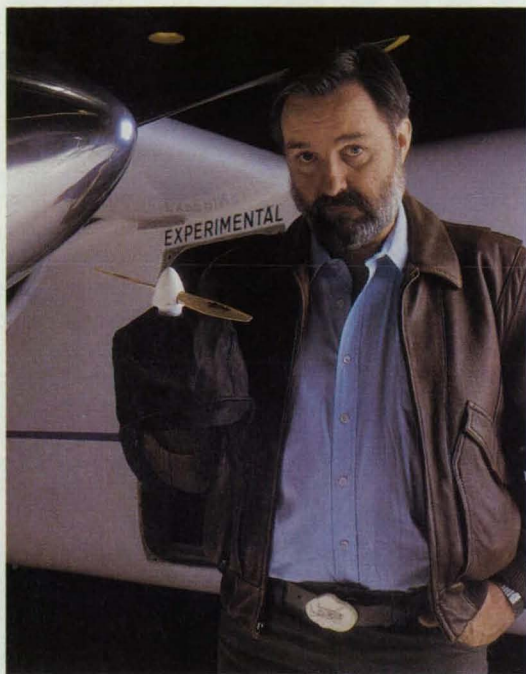
Maybe that's why the first time he sat down to design with Ashlar Vellum, Burt compared the exhilaration to flight. Vellum is the first CAD program with a built-in autopilot.

❖ INDUSTRIAL-STRENGTH CAD THAT THINKS.

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Engineering drawings courtesy of Burt Rutan/Scaled Composites, Inc.

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Burt Rutan. Inventor. Engineer. Another Vellum user with no intention of going back to the drawing board.

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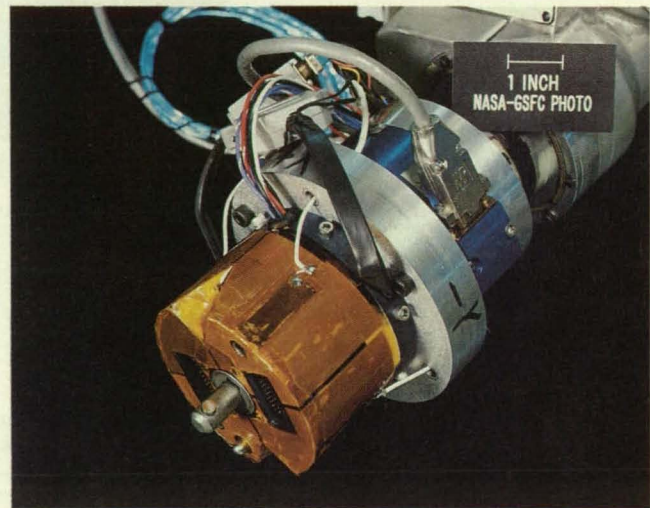


Photo courtesy Goddard Space Flight Center

A new mechanical/electrical coupling described on page 92 is self-aligning and so easy to use that a robot can operate it. One of the coupling's two mating assemblies is shown in the photo above.

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Photo courtesy Ames Research Center

Ames Research Center has produced an algorithm that compensates for computational delay in the presentation of images in a flight simulator, thereby ensuring that the simulated aircraft behaves like the real one and preventing degradation of the pilot's control capability. Turn to the tech brief on page 110.

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ABP 

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on the cover:

Richard Hoover, an astrophysicist at the Marshall Space Flight Center, has earned NASA's Inventor of the Year Award for developing an x-ray microscope that promises to revolutionize biological and medical research. The instrument could produce ultra-high-resolution, high-contrast images of DNA molecules, chromosomes, and other structures inside living cells. See page 14. Photo courtesy Marshall Space Flight Center

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Corporations in Great Britain now will be able to transmit data via rooftop satellite dishes instead of using their current terrestrial-based telecommunications systems. It's the result of British Telecom's new satellite business network using Hughes Aircraft Company's Very Small Aperture Terminal technology. The satellite service provides business customers with high-quality data circuits to potentially thousands of remote sites throughout the U.K. and Europe. Supported applications include database access and downloading, reservations, stock transactions, credit card verifications, electronic mail, data broadcast, and business television.

To ensure the smooth flow of transportation on crowded freeways and highways, Hughes is incorporating many of its existing advanced technologies into an electronic toll road system. This system can perform active, simultaneous, multi-lane communications with vehicles through a single, above-the-road gantry, maintaining continuous, reliable toll collection and enforcement. Among its other communications applications, the Hughes system can also help reroute cars and give traffic advisories. The Hughes electronic toll road system sets the standard for advanced two-way vehicle-to-roadside communications systems.

Inexpensive aluminum clips help trim nearly \$200,000 from the cost of a satellite. The clips were designed and used by Hughes to hold major structural elements of the new HS 601 communications satellites together. Previously, the satellites were bonded together, a time-consuming process because of the close tolerances involved and the approximately one week required for each bond to cure. With about 250 structural joints per satellite, the clips save nearly \$200,000 in hands-on labor per spacecraft. Another benefit of the technique is the elimination of bond testing. Verifying the torque, a much faster process, is all that's required with the new process.

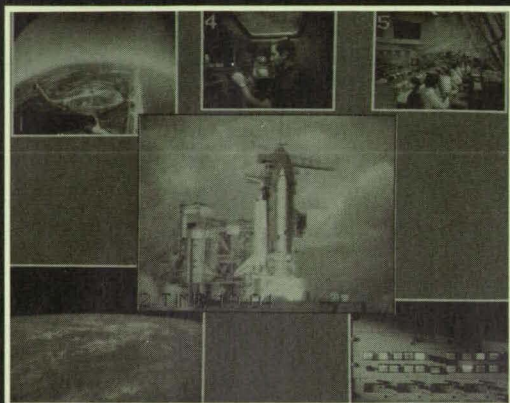
TV viewers in all parts of the country are getting more and more regional coverage, as networks are increasingly turning to satellites for maximum flexibility. Hughes has been a major player in Cable TV distribution, and now will enter into the broadcast network market by teaming with CBS. CBS will purchase 12 transponders on two new Hughes satellites. On a given Sunday afternoon, CBS supplies affiliates with as many as 16 different football game feeds. This enables viewers to get programming most suitable to their interests. CBS began converting from land lines to a satellite-based distribution system in 1982, and now almost all affiliates have their own earth station.

A new audio and video entertainment and communications system will soon enable passengers on Northwest Airlines' jumbo jets to play video games, select movies, make phone calls, receive flight information and order merchandise while aloft. Called Worldlink by the airline, the interactive system will be available at every seat in the aircraft to provide a new level of in-flight passenger entertainment and conveniences. It will be installed on Northwest's Boeing 747s beginning this fall under a \$70 million contract with Hughes. The contract also marks the entry of Hughes into the business of airborne merchandising; the company will establish merchandising centers around the world to maintain inventories of in-flight sales items and fill customer orders.

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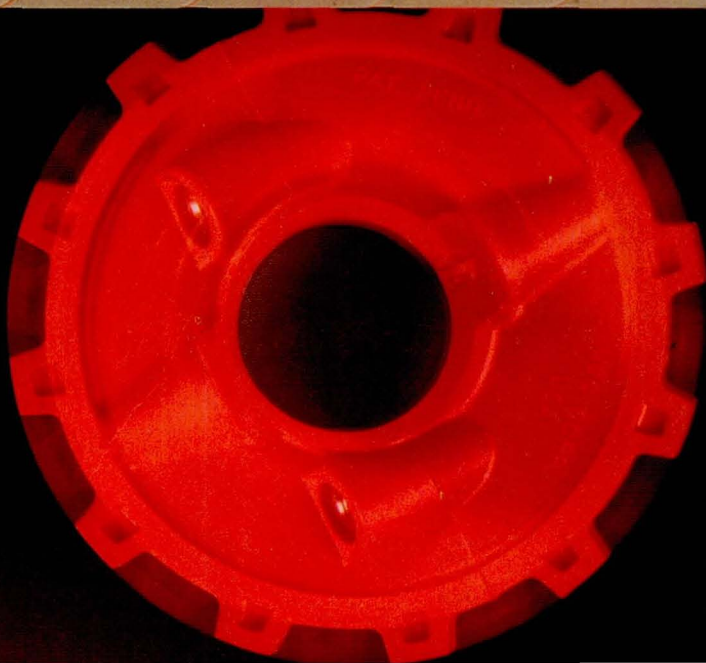
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NASA Inventor Of The Year

Richard Hoover's x-ray microscope will open a new window on the workings of the human body.

Richard B. Hoover

**Marshall Space
Flight Center**

**Invention:
Water Window Imaging
X-Ray Microscope**

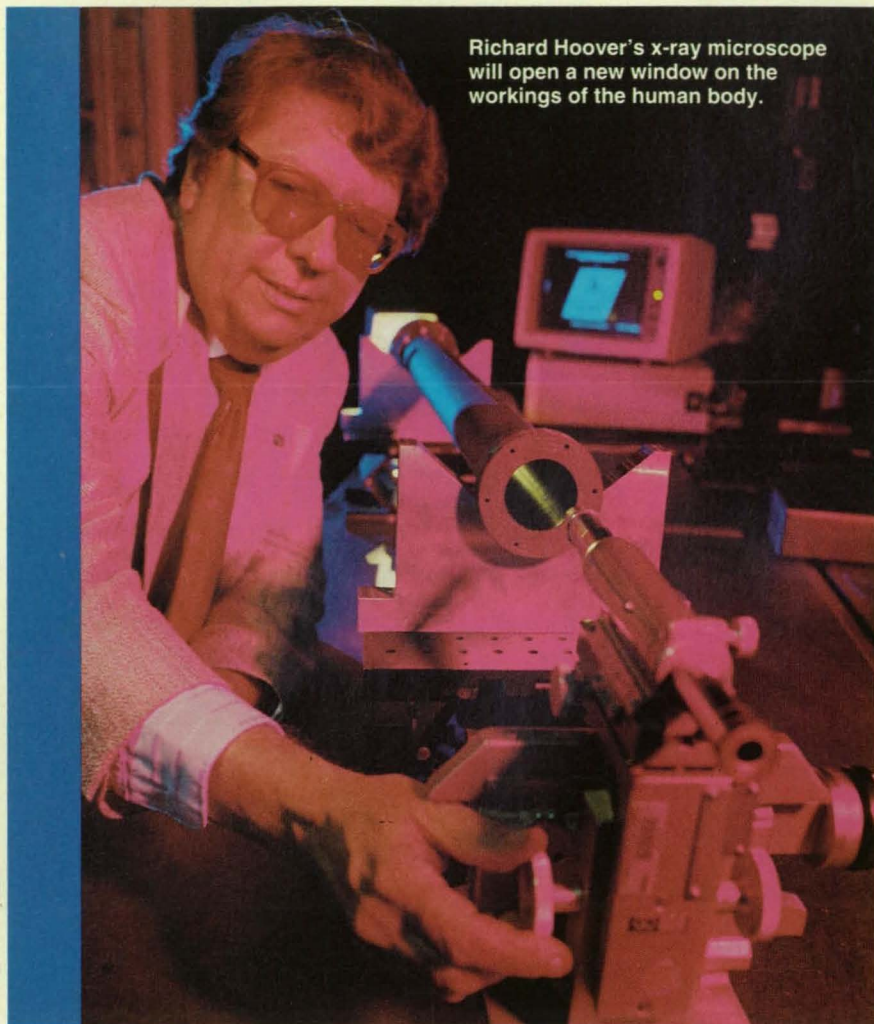


Photo courtesy NASA Marshall

NASA astrophysicist Richard Hoover has won the agency's Inventor of the Year Award for developing a revolutionary x-ray microscope expected to yield images of living cell components with unprecedented resolution and contrast. Its resolution could be so high that it may produce detailed images of DNA molecules—the building blocks of life.

The microscope's mirrors have high reflectivity for x-rays in the range of 23.3 to 43.7 angstroms. Within this narrow "window" of the electromagnetic spectrum, water is highly transparent to x-rays while carbon is highly absorptive. As a result, this region is ideal for viewing the carbon-based microstructures within living cells. Taking advantage of the natural phenomena of varying x-ray absorption spectra eliminates the need for harsh fixatives, dyes, or other chemical additives.

Hoover's invention should prove a boon for a wide range of biological and medical research fields, such as genetic engineering and chemical drug analysis. The microscope promises early tumor cell diagnostic imaging for cancer research as well as structural analysis of the virus causing AIDS. It is suited for ultra-high-resolution studies of proteins, cell nuclei, chromosomes and gene structure, mitochondria, viruses, and DNA and RNA molecules.

"Ultimately, it may be possible to take movies of actual DNA moving within living cells," Hoover said.

Hoover joined NASA in 1966 and currently works as an astrophysicist in the Marshall Center's Solar-Terrestrial Physics Division. He has invented numerous grazing incidence and multilayer x-ray/EUV telescopes, including one that earned him an award nomination last year. Recently, he helped de-

velop high-resolution solar x-ray telescopes, launched aboard sounding rockets in 1987 and 1991, that have produced some of the highest resolution x-ray images ever taken of the sun. Hoover found that optics technologies developed for these telescopes could be applied to the creation of a high-resolution x-ray microscope.

The new microscope utilizes specially-designed multilayer coatings to achieve the optical precision necessary to operate exclusively within the window's narrow bandpass. "Basically, you're painting an incredibly smooth surface with incredibly perfect layers," said Hoover. "The mirror we've made for the microscope using the most advanced flow polishing methods is 1/2-angstrom grade—probably the smoothest surface ever made."

A commercial version of the microscope is about two to three years away,

by Hoover's estimates. He anticipates that it will dramatically change the sub-cellular identification and analysis process. "It will be like the introduction of the scanning electron microscope," he said, "when suddenly so much detail was visible that no one could recognize anything."

The author of more than 100 scientific papers and 11 US patents, Hoover is an internationally recognized authority on diatoms, a class of single-cell algae traditionally used to test microscope objectives.

"As a general rule, people don't work with both telescopes and microscopes,"

he said. "My study of diatoms has made me keenly aware of microscopy techniques and advances in other fields that could help improve them."

Hoover will be NASA's nominee to the National Inventor of the Year competition, the winner of which will be announced in April.

1993 AWARD FINALISTS

Richard Hoover was selected by NASA's Office of General Counsel from a field of eight finalists whose inventions were patented and/or commercially available during 1992. Here's a look at the other nominees' innovative work.

Thomas J. Goodwin and David A. Wolf

Johnson Space Center

Invention: Three-Dimensional Co-Culture Process

Successful synthetic growth and maintenance of large-scale three-dimensional human tissue by Johnson scientists should have broad application in the investigation of human diseases as well as basic biological research. Such tissues could, for example, be used to screen drugs for cancer therapy.

The technique extends the utility of the bioreactor that garnered last year's Inventor of the Year Award for three Johnson scientists, including David Wolf, co-inventor of the new culture process. The bioreactor simulates aspects of microgravity to create an envi-

ronment similar to the amniotic fluid in which the human body develops. Cells require such neutral buoyancy to achieve a three-dimensional structure.

"We needed to make the leap from growing cells in the bioreactor to growing tissue in which the cells are talking to one another as a physiology," said Johnson scientist Thomas Goodwin. "The key lay in duplicating human physiological development in a 3D culture."

The co-culture technique provides the remaining necessary ingredients for tissue development. Two types of mammalian cells from a specific tissue are placed in a bioreactor or similar rotating vessel along with a medium and a matrix. The carefully defined medium must be nutritive but chemically-neutral to permit the cells to initiate their own control. The matrix functions like the cartilaginous skeleton in natural development as a substrate for complex three-dimensional development. Providing the means for both physical contact and biochemical communication between cells results in tissue that both looks and responds like real tissue, according to Goodwin.

Federal laboratories and universities nationwide are applying the technique. Current activities include clinical trials for treatment of cancer patients, regeneration of pancreatic Islet cells for diabetes treatment, and production of ovarian, breast, and colon tumors for high-fidelity cancer research. NASA will pursue fu-

ture application on space station Freedom, where true zero gravity will enable growth of much larger tissue and possibly production of transplantable tissue for use on Earth.

Ruth H. Pater

Langley Research Center

Invention: Low-Toxicity, High-Temperature PMR Polyimide

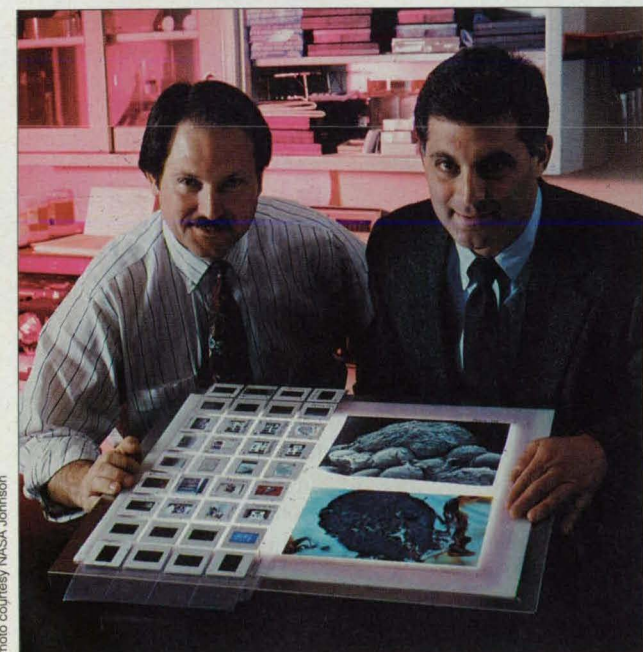
In recent years, ultra-high-performance resins known as polymerization of monomer reactants (PMR) polyimides



Photo courtesy NASA Langley

Ruth Pater, inventor of LaRC-RP46

have been used increasingly in the construction of aircraft engine components. Concerns have arisen, however, over the health risks of PMR-15, the most widely used of these materials. Ruth Pater, a senior polymer scientist at the Langley Research Center, has formulated a new PMR system called LaRC-RP46 that eliminates the hazards of PMR-15 while retaining its attributes.



Thomas Goodwin (left) and David Wolf

The culprit in PMR-15 is 4,4'-methylenedianiline (MDA), a suspected human carcinogen. LaRC-RP46 replaces MDA with 3,4'-oxydianiline, which eliminates the polyimide's toxicity while significantly improving its toughness.

The new polyimide compares well with PMR-15 in many characteristics, offering greater ease of processing, better mechanical properties at both 316° and 371° C, and lower material and processing costs. Readily processed into a high-quality graphite fiber reinforced composite with excellent reproducibility, it also can be used as an adhesive or molding.

LaRC-RP46 prepreps are commercially available from Structural Polymer Systems and resin solids can be purchased from the Dexter Composites Division. According to Pater, LaRC-RP46 should significantly extend the uses of PMR type polyimides. Boeing, Rohr Industries, General Electric, and Lockheed are evaluating its use in aircraft engine parts such as cowlings and fan blades. Future applications may include high-speed civil aircraft, a molded neat resin part for the CRAFT-Cassini satellite, and composite vessels for use in hostile environments.

John M. Vranish and Robert L. McConnell

Goddard Space Flight Center

Invention: Driven Shielding Capacitive Proximity Sensor

The "Capaciflector," a unique capacitive reflector sensor offering unprecedented precision and object detection up to 12 inches away, provides the key to many robotics applications in

space and on Earth.

John Vranish, a Goddard researcher, and Robert McConnell, associate professor of electrical and computer engineering at West Virginia University, originally constructed the sensor to give robots working in space a means to avoid collisions with other objects and, in particular, humans. The key to its outstanding range and sensitivity is an active reflector used to reflect the electric field lines of the sensor capacitor away from the grounded robot arm and towards an oncoming object.

Its utility extends far beyond collision avoidance, according to Vranish. "The Capaciflector solves the fundamental problem of zero gravity by allowing extremely fine adjustments without contact," he said.

The problem with space operations such as docking and assembly is that any contact by the robot may send an object careening away. Since the Capaciflector can detect when contact is imminent to within a few thousands of an inch, embedding the device into a robot arm allows precise guidance for an ultra-soft touch. A peg or screw, for instance, can be "jiggled" into a hole without contact.

Thin, flexible, and conformal, the Capaciflector can be mounted anywhere and even painted over. Further, multiple sensors can be installed in close proximity without crosstalk. NASA Goddard currently is developing an electrically-scanned capacitive camera to provide 3D imaging for identification of obstacles and mating interfaces, thereby further improving control.

Applications in planetary rovers have included Dante, the NASA/Carnegie-Mellon University walking robot, intended to one day explore the surfaces of the moon and Mars. Employing the sensors to detect snow, ice, rocks, and dust improved Dante's footing in missions such as the January 1993 descent into the Mt. Erebus volcano.

The sensor has been licensed to supply various "niche" industrial requirements. One licensee, Computer Applications Systems Inc., Chattanooga, TN, intends to incorporate it into a climbing robot designed to paint TVA electrical distribution towers.

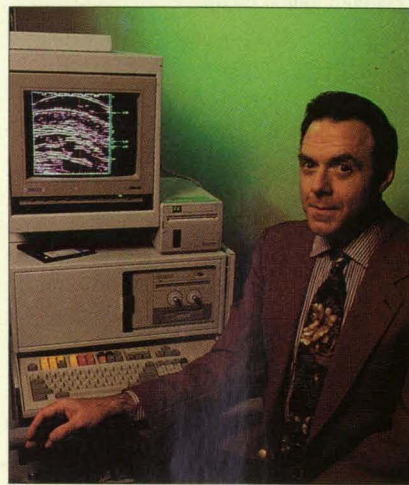
Goddard's Capaciflector, shown attached to a robot during testing

William T. Yost and John H. Cantrell, Jr.

Langley Research Center

Invention: Method and Apparatus for Characterizing Reflected Ultrasonic Pulses

Ultrasonic technology originally developed to locate small cracks in aircraft parts now enables physicians to diagnose severe burn more accurately, which can result in a shorter, less painful, and less costly recovery. The method also has shown promise in locating and sizing cancerous and precancerous lesions.



William Yost, co-inventor of the ultrasonic burn detector

Each year, approximately two million Americans suffer serious burns. The determination of burn depth is critical because it dictates treatment: second-degree burns usually will heal naturally, while third-degree burns are excised and replaced with skin grafts. A wrong assessment can result in bacterial infection, the primary cause of burn victim death.

Until now, physicians have relied on subjective, and error-prone, visual inspection methods to assess burn depth. High-resolution ultrasonic technology developed by William Yost and John Cantrell, senior research physicists at Langley Research Center, permits noninvasive measurement of burn depth to a resolution of better than 60 μ m.

The technique works because burns—whether from flames, scalding, or chemicals—denatures collagen in the skin to change its mass density. The resulting differences in acoustic impedance yield ultrasonic pulse reflection at the boundary between the necrotic and

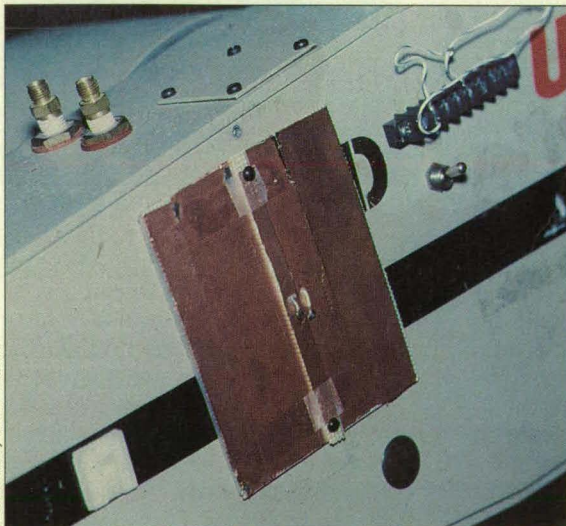


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For More Information Circle No. 522

viable tissue. Burn surgeons have confirmed that the interface corresponds to the actual burn depth.

Licensed exclusively to Supra Medical Corp., Chadds Ford, PA, the technology has been incorporated into the company's Supra Scanner® system, which provides color images of human tissue to a depth of 39 mm and can generate cross-sectional images for identification of cancer and other abnormalities. Further development is focused on early detection of breast tumors and bedsores.

Daniel B. Leiser, Marnell Smith, Rex A. Churchward, and Victor W. Katvala

Ames Research Center

Invention: Toughened Uni-Piece Fibrous Insulation (TUF)

TUF is a low-density composite thermal insulation that out-performs conventional materials in convectively heated environments above 1260° C. According to estimates by Rockwell International, application of TUF to the space shuttle could save more than

\$50 million over the life of the vehicle.

"TUF's greatest attributes are its toughness per unit weight and its machinability—an unusual trait in a ceramic," said Dan Leiser, an Ames researcher involved in the project.

Fabrication of TUF requires a highly porous, silica-based vacuum-formed material (VFM) to serve as a substrate. The VFM is sprayed with a slurry comprising a pigment, a reactive glass frit for added temperature resistance, and a fluxing agent to improve processability. Instead of acting as a coating, the slurry permeates the pores nearer to the substrate's surface, resulting in a material with a broad density gradient—very dense toward the outside and increasingly less dense within.

TUF is the first of a new class of composites known as functional gradient materials, in which composition varies throughout the material. "Integrating two materials intended to serve two different purposes enables you to concentrate the tough substance on the outside where it is needed most without adding density to the inside," explained Leiser.

In addition, eliminating the instantaneous interface between substrate and coating provides a support structure to resist impact. These traits as well as its improved optical and thermochemical stability in a reentry heating environment render TUF well-suited for space shuttle applications. TUF also is a can-

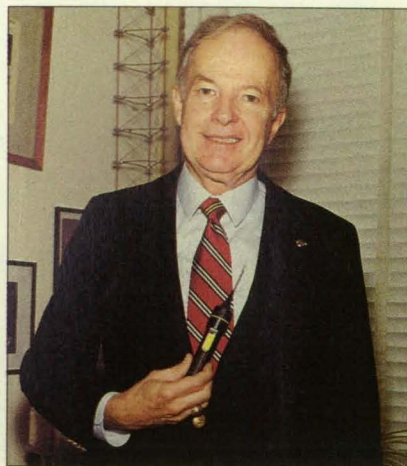
didate for the Pathfinder thermal protection system and a component of heat shields for the National AeroSpace Plane and B-2 aircraft, and has potential application in automobile engines.

Earl Angulo

Goddard Space Flight Center

Invention: Device for Removing Foreign Objects From Anatomic Organs

Extracting foreign objects from human organs such as the ear canal often requires a physician to force a large and rigid instrument past the object to grasp it, which poses grave risks to the organ. Earl Angulo, head of Goddard's Electromechanical Branch, has de-



Mr. Angulo's probe promises to improve the safety of medical procedures.

signed an instrument that eliminates such risks by incorporating a shape-memory-effect (SME) alloy at its tip.

The device relies upon the ability of SME alloys such as Nitinol to "remember" a shape programmed at a specific temperature and resume the shape whenever it is returned to that temperature. Angulo has exploited this property to fashion a tip that assumes one shape for insertion and another for object retrieval.

The device is constructed using a small, flat loop of SME wire heated and then molded into the shape of a hook or curet. Once cooled, the wire can be reshaped into a flat loop for easy insertion past the object lodged in the organ canal. Electrical current is passed through the wire, heating it to the precise temperature at which it will resume the previously-programmed hook shape and allowing the physician to grasp and remove the object.



From left: Rex Churchward, Victor Katvala, and Daniel Leiser

The tip can be altered to serve in a variety of medical situations; one version of the device features two wire loops which assume the shape of tweezers when heated.

Mr. Angulo, who has previous experience with both SME alloys and medical device design, was enlisted for the project by Goddard's Technology Utilization Office following an inquiry from an ear, nose, and throat specialist. According to Angulo, numerous calls from doctors, hospitals, and medical device manufacturers, as well as a recent patent licensing application, promise to hasten development and clinical evaluation of the invention.

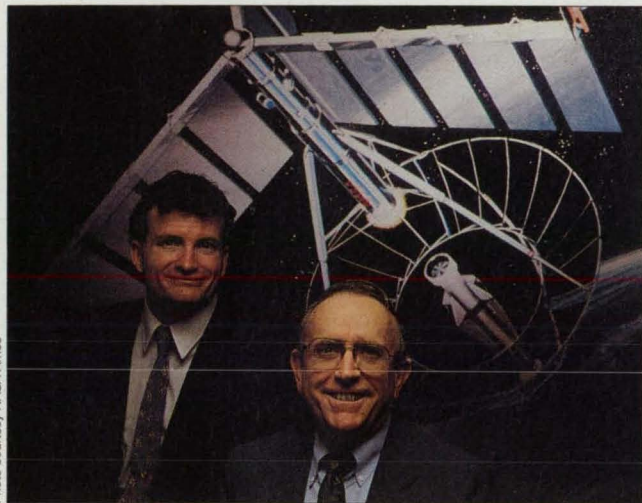
Karl W. Baker and Miles O. Dustin

Lewis Research Center

Invention: Solar Thermal Energy Receiver

An innovative solar heat receiver designed to supply solar heat to Stirling engines in space may also provide efficient electrical power generation for utilities on Earth.

"This is the only solar heat receiver that allows redundancy and delivers heat uniformly without compromising efficiency," said co-inventor Karl Baker.



Karl Baker (left) and Miles Dustin

Concentrated solar energy is received by a collection of heat pipes and stored in canisters on the pipes. Between the canisters and the engine heater head lies a coupling cavity through which the pipes extend to exchange heat with the heater head. This cavity ensures uniform distribution of energy despite uneven impingement or absence of solar energy at times—due, for instance, to passage of the receiver behind a planet with respect to the sun—or failure of one or more heat pipes.

"The receiver uses more standard heat pipes than other designs, which should make construction cheaper and faster," said Baker. "And the few custom-fabricated parts are out of the way of the solar flux."

In addition to solar dynamic power systems, potential terrestrial applications for the receiver include the propeller drive for a Stirling-run robotic submarine. Baker currently is helping to design power systems to enable terrain vehicles on a Mars mission to travel long distances without refueling. □

For information on licensing any of the inventions featured in this article, contact the patent counsel at the NASA center that sponsored the research (see listings on page 22).

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New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the

appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced

at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 22). NASA's patent-licensing program to encourage commercial development is described on page 22.

Power Converters Maximize Outputs of Solar Cell Strings

Microprocessor-controlled dc-to-dc power converters maximize the power transferred from solar photovoltaic strings to storage batteries and other electrical loads. These converters can help in utilizing large solar photovoltaic arrays most effectively with respect to cost, size, and weight. (See page 34)

Video-Level Monitor

A video-level monitor provides full-scene monitoring of the video and indicates the level of the brightest portion. This circuit was designed to be non-specific and can be inserted in any conventional closed-circuit camera system. (See page 36)

Shape-Memory-Alloy Release Mechanism

This electrically activated mechanism would not have the disadvantage of pyrotechnic mechanisms. Like a pyrotechnic release mechanism, it would separate attached objects quickly by remote control; however, unlike pyrotechnic devices, it would not create a hazard or cause damage. (See page 89)

Thin Hot-Film Sensors on Polyimide Film

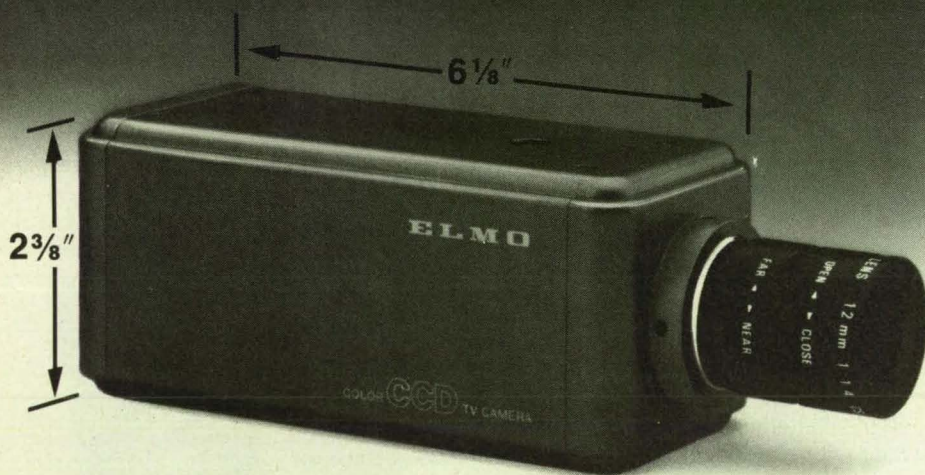
An array of closely spaced hot-film sensors nonintrusively detects laminar boundary-layer transitions with a resolution as high as 0.050 in. (1.3 mm). These films are formed by a combination of vacuum deposition and photolithography. (See page 102)

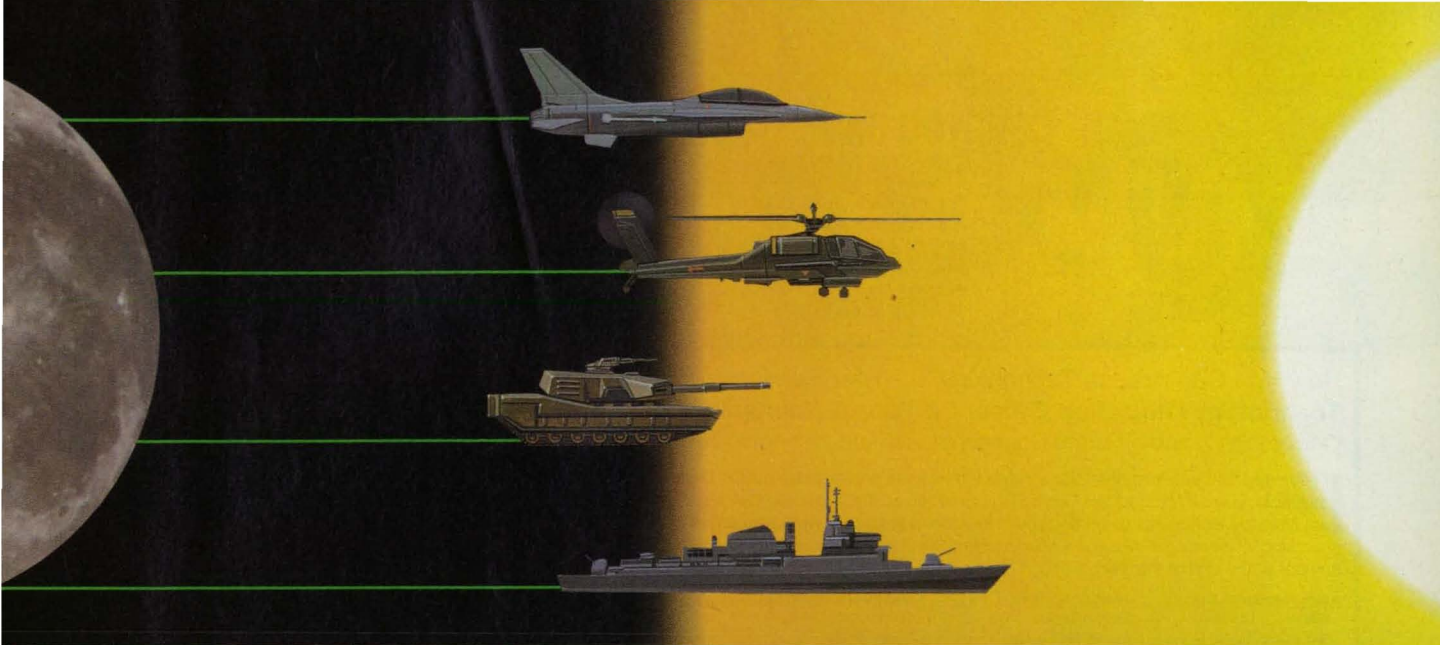
In Vitro, Matrix-Free Formation of Solid Tumor Spheroids

A clinostatic bioreactor promotes the formation of relatively large solid tumor spheroids that have exhibited diameters from 750 to 2,100 μm . The process may be useful in studying the efficacy of chemotherapeutic agents and in the study of interactions between cells that are not constrained by solid matrices. (See page 115)

Prosthetic Hand With Two Gripping Fingers

A prosthetic hand was developed for an amputee who retains a significant portion of a forearm. Rotation of the remaining part of the forearm controls one of the fingers. (See page 116)





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We've outlined below NASA's Technology Transfer Network—named the participants, described their services, and listed the individuals you can contact for more information relating to your specific needs. We encourage you to make use of the information, access, and applications services offered.

How You Can Access Technology Transfer Services At NASA Field Centers:

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If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP). If a TSP is not available, you can contact the Technology Utilization Officer at the NASA Field Center that sponsored the research. He can arrange for assistance in applying the technology by putting you in touch with the people who developed it. If you want information about the patent status of a technology or are interested in licensing a NASA invention, contact the Patent Counsel at the NASA Field Center that sponsored the research. Refer to the NASA reference number at the end of the Tech Brief.

Ames Research Ctr.
Technology Utilization
Officer: Geoffrey S. Lee
Mail Code 223-3
Moffett Field, CA 94035
(415) 604-4044
Patent Counsel:
Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 604-5104

Lewis Research Center
Technology Utilization
Officer: Anthony F.
Ratajczak
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5568
Patent Counsel:
Gene E. Shook
Mail Code LE-LAW
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5753

**John C. Stennis
Space Center**
Acting Technology
Utilization Officer:
Charles Hill
Code HA-30
Stennis Space Center,
MS 39529
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**John F. Kennedy
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Technology Utilization
Officer: James A.
Aliberti
Mail Stop PT-PAT-A
Kennedy Space
Center, FL 32899
(407) 867-3017
Patent Counsel:
Bill Sheehan
Mail Code PT-PAT
Kennedy Space
Center, FL 32899
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Langley Research Ctr.
Technology Utilization
Officer: Joseph J.
Mathis, Jr.
Head, TU & AO Office
Mail Stop 200
Hampton, VA 23681-0001
(804) 864-2484
Patent Counsel:
Dr. George F. Helfrich
Mail Stop 143
Hampton, VA 23681-0001
(804) 864-3221

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Center**
Technology Utilization
Officer: Dr. George Alcorn
Mail Code 702
Greenbelt, MD 20771
(301) 286-5810
Patent Counsel:
R. Dennis Marchant
Mail Code 204
Greenbelt, MD 20771
(301) 286-7351

Jet Propulsion Lab.
NASA Resident Office
Technology Utilization
Officer: Arif Husain
Mail Stop 180-801D
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4862
Patent Counsel:
Thomas H. Jones
Mail Code 180-801G
4800 Oak Grove Drive
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Code AT01
Marshall Space Flight
Center,
AL 35812
(205) 544-2223
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Mail Code CC01
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Center,
AL 35812
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Patent Counsel:
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Mail Code AL3
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Special Focus: Computer-Aided Design and Engineering

Faster, Easier Finite-Element Modeling of Weld Offsets

Offsets are modeled as fictitious deformations of softened materials.

Marshall Space Flight Center, Alabama

Finite-element mathematical models of weld offsets can be generated more quickly and easily than before by use of a technique based on the analysis of fictitious stresses and strains in the welded parts. The mathematical modeling of weld offsets is a common problem in the design of pump housings. Heretofore, weld offsets have been modeled by use of a spreadsheet program on a personal computer; the modeling procedure has consumed much time, especially in cases in which there have been multiple offsets.

In the faster, easier technique, the material in the weld zone is fictitiously softened to a negligibly low modulus of elasticity [e.g., 0.1 psi (about 700 Pa)], and the material is considered to be deformed to the specified offset (see Figure 1). The displacements caused by the deformation are then computed by analysis of static stresses and strains in the fictitiously deformed material, using the specified offset as a displacement boundary condition. By use of a simple FORTRAN program, the result-

ing displacements are then added to the coordinates of the corresponding nodes of the original (nonoffset) mathematical model of the welded part.

This technique can be used to modify a large finite-element mathematical model to any desired weld offset configuration in a short time. The modified model (see Fig-

ure 2) contains no abrupt discontinuities in the weld zones.

This work was done by C. Chen Hong and Bradley E. Lichwala of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available.

MFS-29868

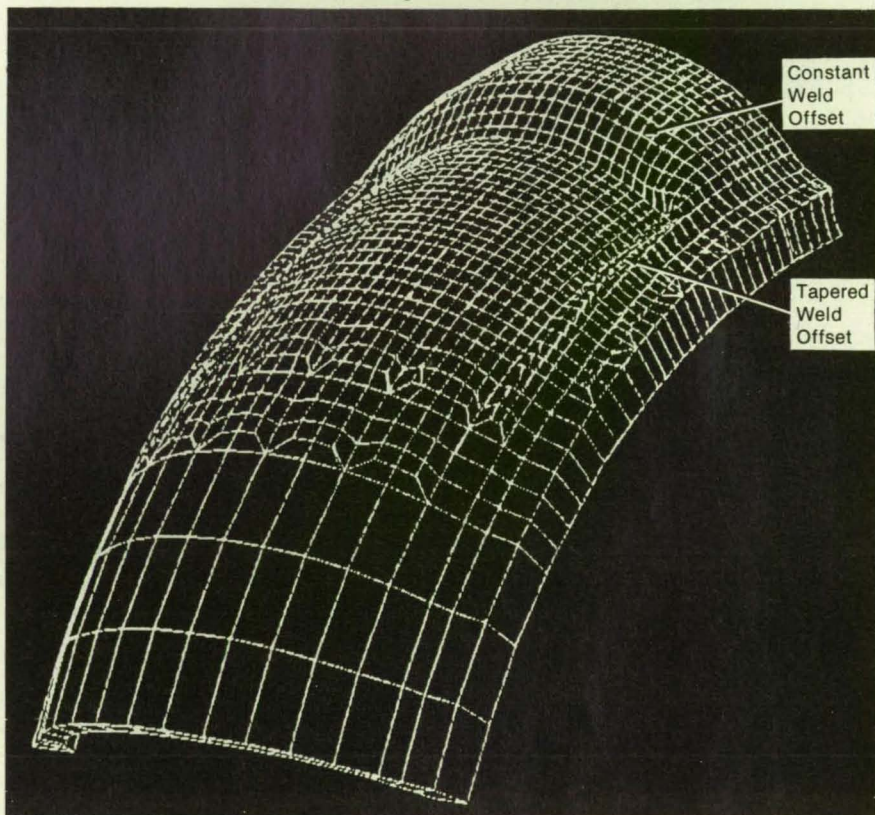


Figure 2. These **Constant and Tapered Weld Offsets** in a pump housing were computed by use of the ANSYS finite-element program on a SUN Microsystems® computer.

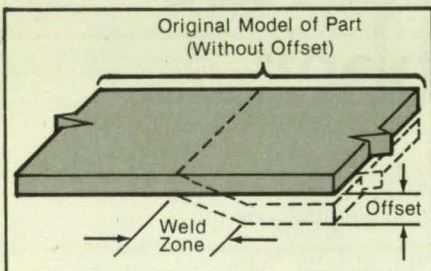


Figure 1. The **Weld Offset** is mathematically modeled, for the purpose of computing its shape, as though it were produced by deformation of the fictitiously softened welded material.

Integrated Approach to Design and Analysis of Systems

An object-oriented fault-tree representation unifies evaluation of reliability and diagnosis of faults.

Ames Research Center, Moffett Field, California

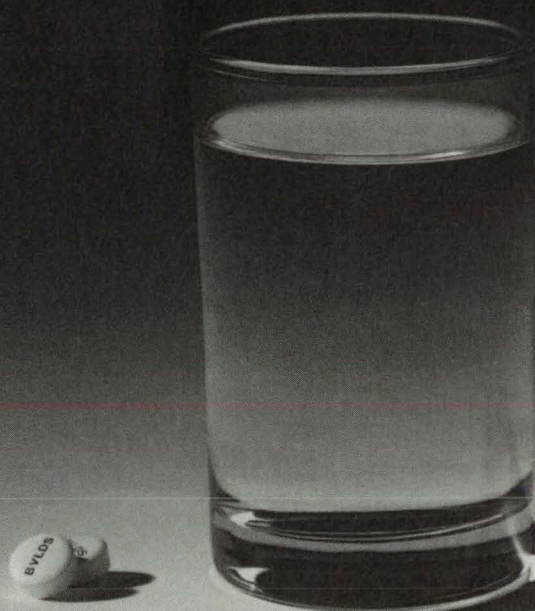
An integrated approach is leading to the development of powerful computer programs that will analyze the reliabilities and diagnose the faults of complicated systems of equipment and computer programs. Examples of such equipment-and-program systems include advanced aircraft, spacecraft, factories, and powerplants, all equipped with computerized control subsystems. The integrated approach is motivated by

(1) the need to design such equipment-and-program systems to be highly reliable and, for this purpose, (2) the need to combine analyses of the functions of hardware and software subsystems in mathematical models that are flexible enough to represent the individual behaviors of, and interactions among, these subsystems.

In the integrated approach, the logical relationships among the components of

the hardware/software system to be analyzed/diagnosed are specified in a fault tree representation by use of object-oriented programming. [The object-oriented programming/fault tree concept is described more fully in "Object-Oriented Algorithm for Evaluation of Fault Trees" (ARC-12731), *NASA Tech Briefs*, Vol. 16, No. 2 (1992), page 108.] Fault trees were selected because they are flexible mathematical mod-

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els that are widely used in aerospace applications, and they give concise, structured representations of the behaviors of systems.

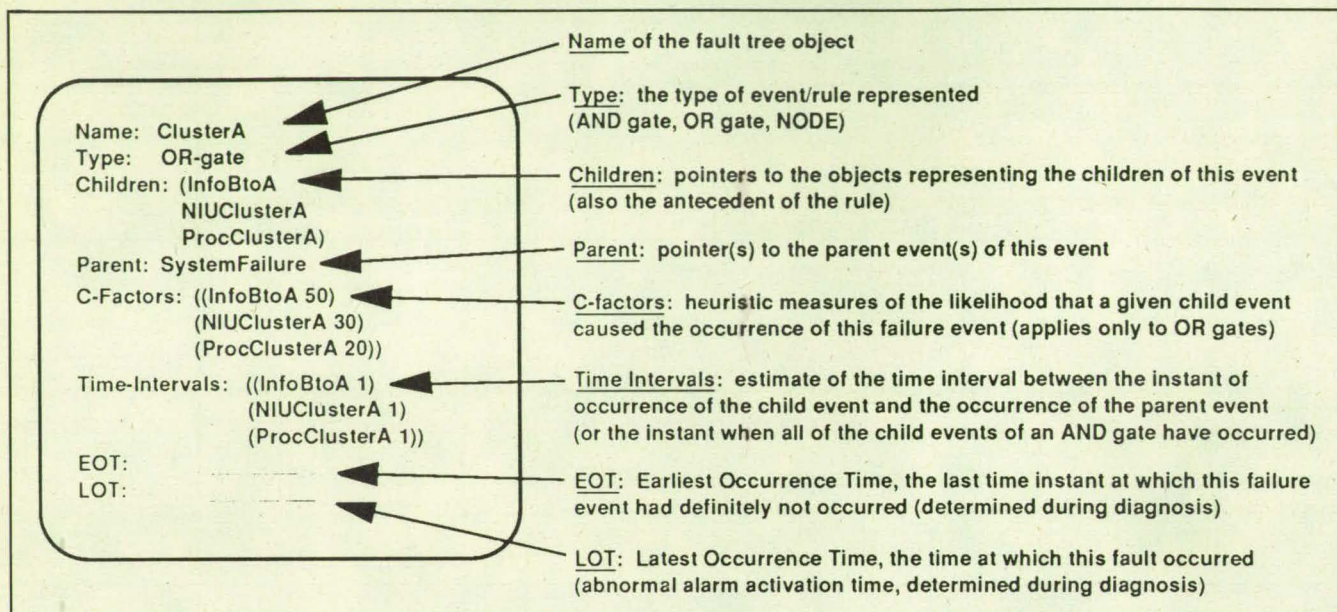
The object-oriented fault tree representation lends itself well to the quantitative analysis of reliability as described in the noted previous article. It is necessary to incorporate additional information into the fault tree for use in the diagnosis of faults. In summary, this involves the use of augmented fault tree objects to contain the additional information, including data equivalent to the "if ... then" diagnostic rules

(see figure).

The OBREL and FTDS computer programs provide fault tree representations according to this approach for the quantitative evaluation of reliability and the diagnosis of faults, respectively. Both of these programs have access to a central, object-oriented knowledge base. Both provide interactive graphical displays, through which engineers can easily enter data and observe results. Thus, they can quickly and easily learn the effects of changes in designs. These programs improve the design process by eliminating the develop-

ment of redundant mathematical models at various stages. The object-oriented mathematical models in these programs are particularly useful inasmuch as they can be modified easily to characterize various aspects of the behaviors of systems, thereby promoting the development of additional analysis software that will have access to the same data base.

This work was done by F. A. Patterson-Hine and David L. Iverson of Ames Research Center. For further information, Circle 13 on the TSP Request Card. ARC-12775



An **Augmented Fault tree Object** contains more information than does a fault tree object used in the quantitative analysis of reliability. The additional information is needed to diagnose faults in the system represented by the fault tree.

Neural Network Would Estimate Fatigue Life

The processor would learn mappings between sequences of loads and fatigue damage.

Lewis Research Center, Cleveland, Ohio

A conceptual data processor to be built around a neural network would provide real-time estimates of the fatigue life of simple mechanical components. This conceptual processor is intended to be the forerunner of more-advanced processors that would estimate the remaining lives of components that are stressed near their mechanical and thermal limits in turbine engines and other complicated, high-performance machinery. Real-time estimates of accumulated fatigue damage and remaining life before mechanical failure would be useful in scheduling maintenance and controlling operation to extend the overall life of the machinery.

The processor (see figure) would include the neural network and a preprocessor. The preprocessor would perform relatively simple "front-end" processing to increase the computational efficiency of the neural network. First, the preprocessor would extract peak-to-peak load transitions by com-

paring the loads sampled at three successive times. Once an extremal load value was identified, it would be stored in a shift-register type of buffer, the contents of which would be analyzed repeatedly to detect load cycles. When a load cycle was identified, the contents of the shift register would be sent to the neural network. If not, the shift register would be made ready to receive an additional extremal load value.

Each input unit of the neural network would be in one-to-one correspondence with each buffer of the shift register of the preprocessor. This means that a peak value of the load sequence would be fanned out to each neuron of the first hidden layer in the network. The activation function of each neuron would be chosen to be given by

$$\text{output} = \frac{1}{1 + \exp(-\text{input})}$$

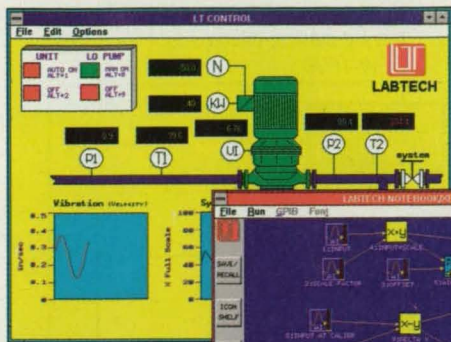
where the input would be the sum of the weighted outputs of all the connected neurons in the preceding layer, plus a thresh-

old term. The output of the network would contribute to the computed fatigue damage only when the preprocessor identified a load cycle.

The concept was tested by computer simulation, for a neural network with 15 input units, 100 neurons in the first hidden layer, 50 neurons in the second hidden layer, and 1 neuron in the output layer, using fatigue and load data for a uniaxial steel specimen. The network learned the mapping between the sequence of applied loads and the fatigue damage. In view of its performance in this application, the neural network may also be capable of similar computations for biaxial and triaxial specimens and for components of complicated shape (e.g., turbine blades).

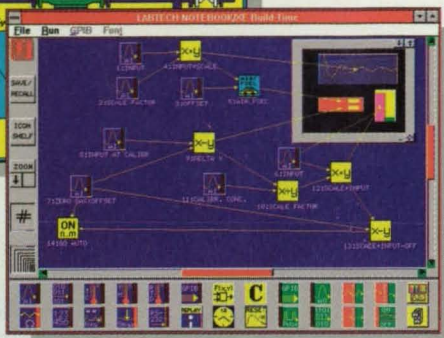
The significance of this approach lies in generality, speed, and robustness: Mappings between sequences of loads and the fatigue damage can be extracted from experimental data without requiring any

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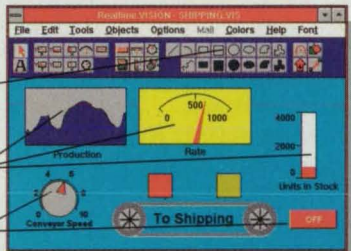
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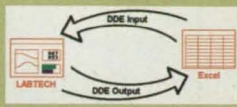
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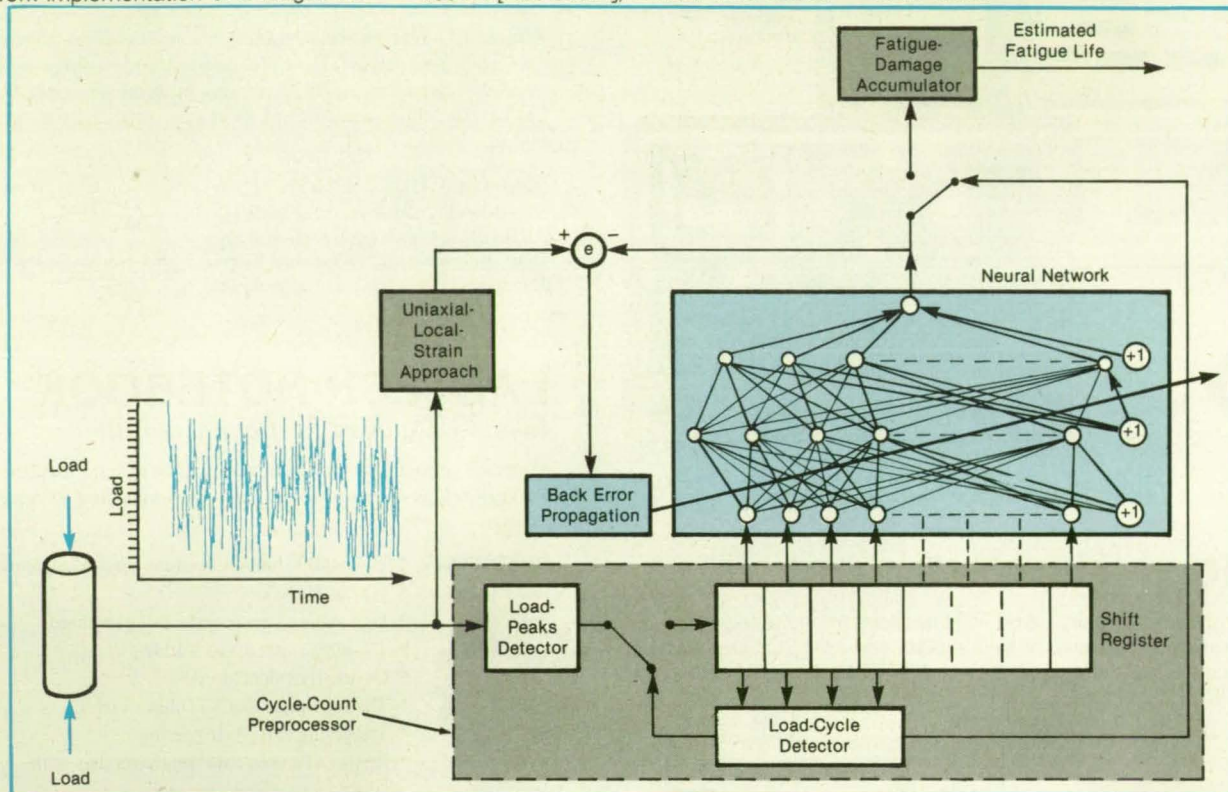
knowledge of the stress-vs.-strain behavior of the component in question. The parallel architecture of the neural network enables it to compute rapidly enough to produce estimates in real time, even in the presence of high-frequency vibrations. Because of its distributed nature, the neural-network implementation of a fatigue-life

estimator is expected to be robust and reliable, enabling use even in such hostile environments as rocket engines.

This work was done by W. Merrill of **Lewis Research Center** and T. Troudet of Sverdrup Technology, Inc. Further information may be found in NASA TM-103117 [N90-21564], "A Real Time Neural

Net Estimator of Fatigue Life."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15305



The **Fatigue-Life Estimator** would provide real-time estimates of the remaining fatigue life of a stressed uniaxial specimen.

Generating Finite-Element Models of Composite Materials

This program starts at the micromechanical level, from simple inputs supplied by the user.

COMGEN (COMposite Model GENerator) is an interactive FORTRAN program that can be used to create a wide variety of finite-element models of continuous-fiber composite materials at the micromechanical level. It quickly generates batch or "session files" to be submitted to the finite-element preprocessor and postprocessor program, PATRAN (PDA Engineering, Costa Mesa, CA).

A significant percentage of time spent in a typical finite-element analysis is taken up in the modeling process and assignment of loads and constraints. To perform such an analysis in the absence of a program like COMGEN, the analyst must not only be well versed in the art of finite-element modeling but must also be familiar with some sort of preprocessing software to complete the task expediently.

In modeling a composite material, COMGEN incorporates the assumption that the constituents of the material can be represented by a "unit cell" of a fiber surrounded by matrix material. Cells of two basic types are available. In the first type, the fiber is positioned in the center of a square matrix cell, and the cells are packed in a square pattern. In the second type, the packing pattern is hexagonal, and the fiber is centered in a hexagonal matrix cell. Different models can be created by use of combinations of square and hexagonal packing schemes. Variations include two- and three-dimensional cases, models with fiber/matrix interfaces, and different constructions of unit cells.

Inputs by the user include the diameter and the percent volume of the fibers in the composite to be analyzed. In addition, various mesh densities, boundary conditions, and loads can be assigned to the models within COMGEN. The PATRAN program then uses a COMGEN session file to generate finite-element models and their associated loads, which can then be translated to virtually any finite-element analysis code, such as NASTRAN or MARC.

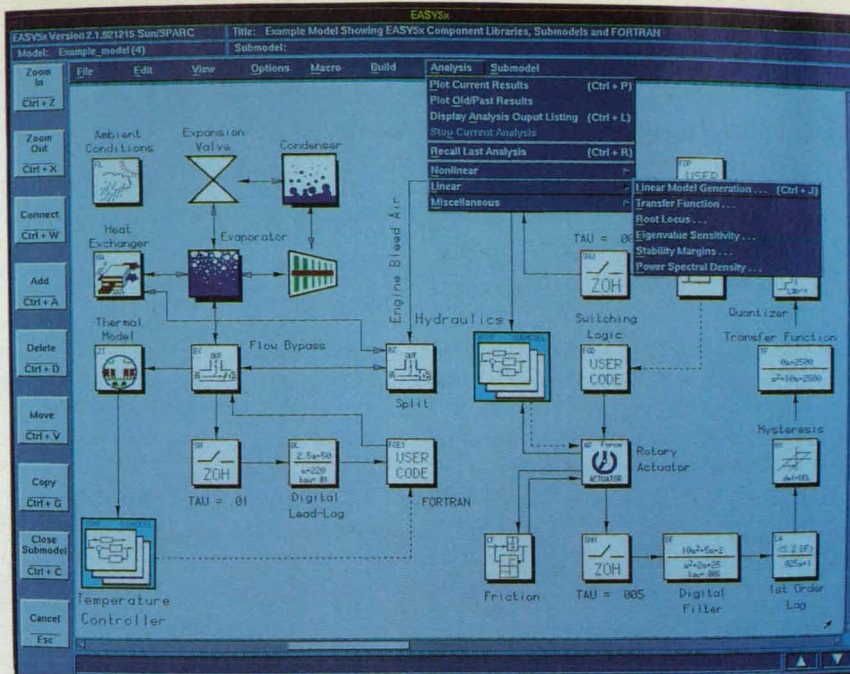
COMGEN is written in FORTRAN 77

and has been implemented on DEC VAX-series computers under VMS and SGI IRIS-series workstations under IRIX. COMGEN requires PATRAN to complete the model. The VAX VMS version is available on a 5.25-in. (13.3-cm) 360K MS-DOS format diskette (standard distribution medium) or a 9-track, 1,600-bit/in. (630-bit/cm) magnetic tape in DEC VAX FILES-11 format, and it requires about 124K of main memory. The standard distribution medium for the IRIS version is a 0.25-in. (6.4-mm) streaming-magnetic-tape cartridge in UNIX tar format. The memory requirement for the IRIS version is 627K. COMGEN was developed in 1990.

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This program was written by M. E. Melis of **Lewis Research Center**. For further information, Circle 78 on the TSP Request Card.

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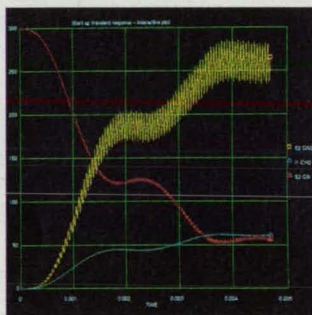
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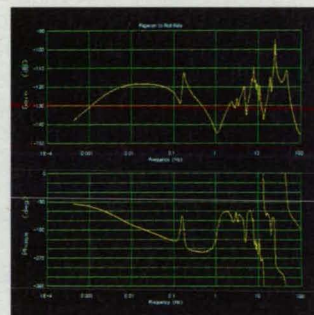
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This program incorporates refined techniques of analysis of subsonic flows.

The Subsonic Wind Tunnel Performance Analysis computer program was developed as an aid in the design and analysis of subsonic wind tunnels. It brings together and refines previously scattered and oversimplified techniques that have been used for the design of, and the prediction of losses in, the components of subsonic wind tunnels. It implements a system of equations for determining the total pressure losses and provides general guidelines for the design of diffusers, contractions, corners, and the inlets and exits of nonreturn tunnels.

The algorithms used in the program are applicable to compressible flow through most closed- or open-throated, single-return, double-return, or nonreturn wind tunnels or ducts. A comparison of performances calculated by the program with those achieved by several existing facilities showed generally good agreement. Any system through which air flows and that includes turns, fans, contractions, and the like (e.g., a heating, ventilating, and/or air-conditioning system) can be analyzed by use of this software. This program is an update of ARC-11138 that includes PC compatibility and an improved user interface.

The method of analysis of losses implemented by the program is a synthesis of theoretical and empirical techniques. Gen-

erally, the algorithms used are those that have been substantiated by experimental tests. The basic flow-state parameters used by the program are determined from input information about the reference control section and the test section. These parameters were derived from standard relationships for compressible flow.

The local flow conditions, including mach number, Reynolds number, and coefficient of friction, are determined for each end of each component or section. The loss in total pressure caused by each section is calculated in a form nondimensionalized by local dynamic pressure. The individual losses are based on the nature of the section, local flow conditions, input geometry, and parameters. The program computes losses in such typical wind-tunnel sections as straight and corner ducts of constant cross-sectional area, open-throat ducts, contractions, diffusing corners, diffusers, exits, flow straighteners, and fans. Fixed, known losses are also included.

Input to this program consists of data that describe the types, shapes, sizes, and various parameters of the sections. Output from the program consists of a tabulation of the performance-related parameters for each section of the wind-tunnel circuit, and of the overall performance values, which include the total length of the wind-tunnel circuit, the total pressure losses and energy ratios for the circuit, and the total operating power required. If requested, the output also includes an echo of the input data, a summary of the circuit characteristics, and plots of the computed cumulative pressure losses and wall-pressure differentials.

The Subsonic Wind Tunnel Performance Analysis software is written in FORTRAN 77 (71 percent) and BASIC (29 percent) for IBM PC-series computers and compatibles running MS-DOS 2.1 or higher. The required equipment includes either an 80286 or an 80386 processor, a math coprocessor, and 640K of main memory. The PERFORM analysis software is written for the RM/FORTRAN v2.4 compiler. This portion of the code is portable to other computers that support standard FORTRAN 77 compilers. Source code and executable code for the PC are included with the distribution. They are compressed by use of the PKWARE archiving software tool; the utility software to unarchive the files, PKUNZIP.EXE, is included. With the PERFINTEP program interface, the user can enter the wind-tunnel characteristics via a menu-driven program, but this is available only for the PC. The standard distribution medium for this package is a 5.25-in. (13.34-cm), 360K diskette in MS-DOS format. This software package was developed in 1990.

DEC, VAX, and VMS are trademarks of Digital Equipment Corp. RM/FORTRAN is a trademark of Ryan McFarland Corp. PERFORM is a trademark of Prime Computer Inc. MS-DOS is a registered trademark of Microsoft Corp.

This update was written by C. Decker of Ames Research Center; the original program was written by W. T. Eckert of NASA Headquarters and K. W. Mort and J. Jope of Ames Research Center. For further information, Circle 66 on the TSP Request Card.
ARC-13129

Program Helps Decompose Complicated Design Problems

Time is saved by intelligent decomposition into smaller, interrelated problems.

Many engineering systems are large and multidisciplinary. Before the design of such new complex systems as large platforms in outer space can begin, the possible interactions among subsystems and their parts must be determined. Once this determination has been made, the proposed system can be decomposed to identify its hierarchical structure. DeMAID (A Design Manager's Aide for Intelligent Decomposition) is a knowledge-based software system for ordering the sequence of modules (defined below) and identifying a possible multilevel structure for the design problem. DeMAID displays the modules in an $N \times N$ matrix format

(called a "design structure" matrix). (For the purpose of this article, a module is defined as any process that generates an output and may or may not require an input.)

Although DeMAID requires an investment of time to generate and refine the list of modules for input, it could save a considerable amount of money and time in the total design process, particularly in new design problems in which the ordering of the modules has not been defined. This program can also be implemented to examine an assembly-line process or the ordering of tasks and milestones.

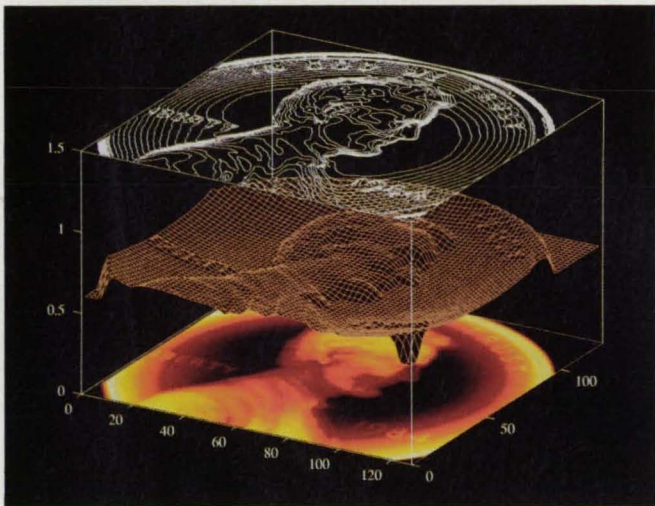
The decomposition of a complex design system into subsystems requires the judgement of the design manager. DeMAID reorders and groups the modules on the basis of the links (interactions) among the modules, helping the design manager make decomposition decisions early in the design cycle. These links can be deleted interactively. The

modules are grouped into circuits (the subsystems) and displayed in the matrix format.

Feedback links, which indicate iterative processes, are minimized and occur only within subsystems. Inasmuch as there are no feedback links among the circuits, the circuits can be displayed in a multilevel format. Thus, a large amount of information is reduced to one or two displays that are stored for later retrieval and modification. The design manager and leaders of the design teams then have a visual display of the design problem and the intricate interactions among the different modules.

The design manager could save a substantial amount of time if circuits on the same level of the multilevel structure are executed in parallel. DeMAID estimates the time saved on the basis of the number of available processors. In addition to decomposing the system into subsystems, DeMAID examines the dependencies of a problem with design

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Three views of the surface height of a penny show user customizable object-oriented graphics in MATLAB 4.0. Data courtesy of NIST.

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Spectrogram of Handel's Hallelujah Chorus, computed and displayed with MATLAB 4.0 and the Signal Processing Toolbox.

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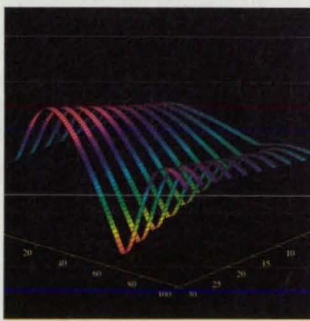
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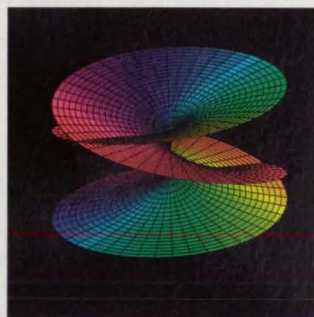
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and behavior variables and creates a dependency matrix. This matrix shows the relationship among the independent design variables and the dependent constraint and objective functions.

DeMAID is based on knowledge-base techniques to provide flexibility and ease in adding new capabilities. Although DeMAID was originally written for design problems, it has proven to be very general in solving any problem that involves modules (processes) that take inputs and generate outputs. For example, one group is applying DeMAID to gain understanding of the flow of data of a very large computer program. In this example, the modules are the subroutines of the program.

The user begins the design of a system by determining the level of modules to be ordered. The level is the "granularity" of the problem. The design manager may wish to examine disciplines (a coarse model), analysis programs, or the data level (a fine model). Once the system is divided into these modules, the user determines the input and output of each module, cre-

ating a data file for the main program.

DeMAID is executed through a system of menus. The user can choose to plan, schedule, display the $N \times N$ matrix, display the multilevel organization, examine parallelism, or examine the dependency matrix. The main program calls a subroutine that reads a rule file and a data file, asserts facts into the knowledge base, and executes the CLIPS inference engine.

DeMAID is available in two versions for different computers: a Macintosh version, which is written in C Language, using Symantec's Think C 4.0; and a VAX VMS version, which is written in FORTRAN 77. The Macintosh version requires 1.5 Mb of random-access memory, system software 6.0.2 or later, and CLIPS 4.3. The Macintosh version is available on a set of four 3.5-in. (8.89-cm), 800K Macintosh-format diskettes and includes the source code for CLIPS 4.3 and sample input. The VAX VMS version requires 200K of memory and the CLIPS 4.2 run-time library and was designed to run with the standard VAX GKS graphics system, but can

easily be modified to run with other graphics systems. The VAX VMS version of DeMAID includes the CLIPS 4.2 run-time library for DEC VAX-series computers running VMS and is available on a 9-track, 1,600-bit/in. (630-bit/cm) magnetic tape in VAX FILES-11 format (standard distribution medium) or in VAX BACKUP format on a TK50 tape cartridge. The documentation available for this package is for DeMAID only; the documentation for CLIPS 4.3 is available separately. The VAX VMS version of DeMAID was developed in 1989 and updated in 1990. The Macintosh version was released in 1991.

Symantec and Think C are trademarks of Symantec Corp. Macintosh is a registered trademark of Apple Computer, Inc. DEC, VAX, VMS, and TK50 are trademarks of Digital Equipment Corp.

This program was written by James L. Rogers, Jr. of Langley Research Center. For further information, Circle 67 on the TSP Request Card.
LAR-14793

Computer Code Aids Design of Wings

AERO2S rapidly estimates aerodynamic characteristics.

The AERO2S computer code was developed to aid design engineers in the selection and evaluation of aerodynamically efficient wing/canard and wing/horizontal-tail configurations that may include simple hinged-flap systems. The code rapidly estimates the longitudinal aerodynamic characteristics of conceptual airplane lifting-surface arrangements.

The code is particularly well suited to configurations that, because of high-speed-flight requirements, must include thin wings with highly swept leading edges. It is applicable to wings with either sharp or rounded leading edges. It provides theoretical pressure distributions over the wing, the canard or horizontal tail, and the deflected flap surfaces. It also provides estimates of the lift, drag, and pitching moments on the wing, which account for attainable leading-edge thrust and leading-edge-separation-vortex forces.

The wing planform information is specified by a series of leading-edge and trailing-edge breakpoints for a right wing panel. Up to 21 pairs of coordinates can be used to describe both the leading and trailing edges. The code has been written to accommodate 2,000 right-panel elements but can easily be modified to accommodate a larger or smaller number of elements, depending on the capacity of the computer. The code provides solutions for wing

surfaces composed of all possible combinations of leading-edge and trailing-edge flap settings provided by the original deflection multipliers and by the flap-deflection multipliers. Up to 25 pairs of leading-edge and trailing-edge flap-deflection schedules can thus be treated simultaneously.

The code also provides for an improved accounting of hinge-line singularities in determination of wing forces and moments. To determine lifting-surface perturbation velocity distributions, the code provides for a maximum of 70 iterations. The program is constructed so that successive runs can be made with a given code entry. To make additional runs, it is necessary only to add an identification record and the namelist data that are to be changed from the previous run.

This code was originally developed in 1989 in FORTRAN V on a CDC 6000 computer system, and was later ported to an MS-DOS environment. Both versions are available from COSMIC. There are only a few differences between the PC version (LAR-14458) and CDC version (LAR-14178) of AERO2S distributed by COSMIC. The CDC version contains one main source code file, while the PC version contains two files because two files can be edited and compiled more easily on a PC. The PC version does not require a FORTRAN compiler that supports NAMELIST because a special INPUT subroutine has been added. The CDC version includes two MODIFY decks, which can be used to improve the code and prevent some errors that occur infrequently, while users of the PC version must make the corresponding

changes in the code manually.

The PC version includes an executable code that was generated with the Ryan McFarland/FORTRAN compiler and requires 253K of random-access memory and an 80x87 math coprocessor. Using this executable code, the sample case requires about 4 hours on an 8-MHz AT-class microcomputer with a coprocessor. The source code conforms to the FORTRAN 77 standard except that it uses variables longer than six characters. With two minor modifications, the PC version should be portable to any computer with a FORTRAN compiler and sufficient memory. The CDC version of AERO2S is available in CDC NOS Internal format on a 9-track, 1,600-bit/in. (630-bit/cm) magnetic tape. The PC version is available on a set of two 5.25-in. (13.34-cm), 360K diskettes in MS-DOS format.

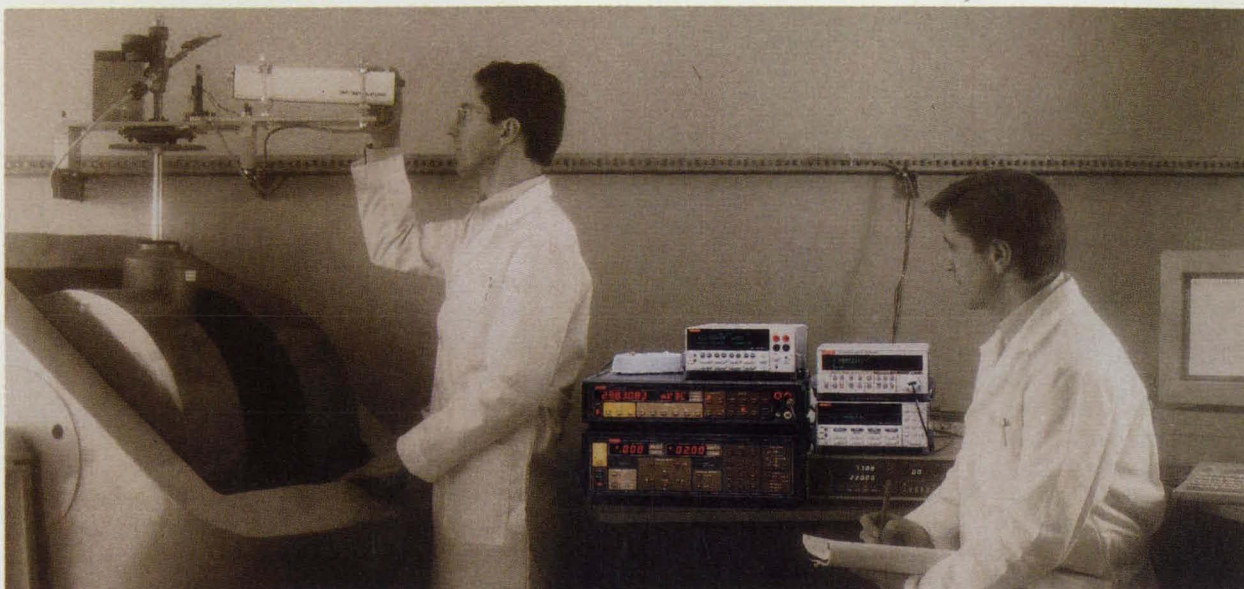
IBM AT is a registered trademark of International Business Machines Corp. MS-DOS is a registered trademark of Microsoft Corp. CDC is a registered trademark of Control Data Corp. NOS is a trademark of Control Data Corp.

This program was written by Harry W. Carlson of Planning Research Corp. and Christine M. Darden of Langley Research Center.

For further information on the CDC version, Circle 96 on the TSP Request Card.
LEW-14178

For further information on the PC version, Circle 97 on the TSP Request Card.
LAR-14458

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Power Converters Maximize Outputs of Solar Cell Strings

Voltages are adjusted iteratively to find the maximum-power operating points.

Goddard Space Flight Center, Greenbelt, Maryland

Microprocessor-controlled dc-to-dc power converters have been devised to maximize the power transferred from solar photovoltaic strings to storage batteries and other electrical loads. These converters can help in utilizing large solar photovoltaic arrays most effectively with respect to cost, size, and weight.

The output of each solar cell can be characterized by a current-vs.-voltage curve that includes a maximum-power point at some voltage, V_{mp} , which lies between zero and the open-circuit voltage. V_{mp} depends on a variety of factors, including the temperature, the level of illumination, the type of cell, the damage by radiation, and the number of cells in series. The voltage at which the maximum power is transferred from the solar cell to the load(s) can differ slightly from V_{mp} and can depend on the aforementioned factors plus the electrical characteristics of the load(s) and intervening circuitry. A power-maximizing dc-to-dc converter of the new type is a pulse-width-modulation buck converter that enables the solar cell to operate at a voltage different from the voltage applied to the load(s) and that maintains the solar-cell-string voltage at or near the value at which maximum power is transferred from the cell to the load(s).

Figure 1 illustrates the functional blocks of a basic power-maximizing circuit. A sensor measures the current delivered to the storage battery and load(s); because the storage battery maintains a nearly constant voltage, this current is assumed to be indicative of the power transferred to the storage battery and load(s). The solar cell is connected to power-input terminals of a tracker unit, which includes the pulse-width-modulation buck dc-to-dc converter circuitry. A differential amplifier in the tracker unit compares the battery voltage with a control voltage supplied by a controller and adjusts the width of pulses accordingly to keep the battery voltage at or near the control voltage.

The controller operates in cycles, during each of which it sets the control voltage at three different values: a nominal operating point, one value slightly above, and one value slightly below. At each voltage setting, the controller waits a few milliseconds for transients to fade, then acquires the output of the current sensor. The voltage setting that yields the greatest cur-

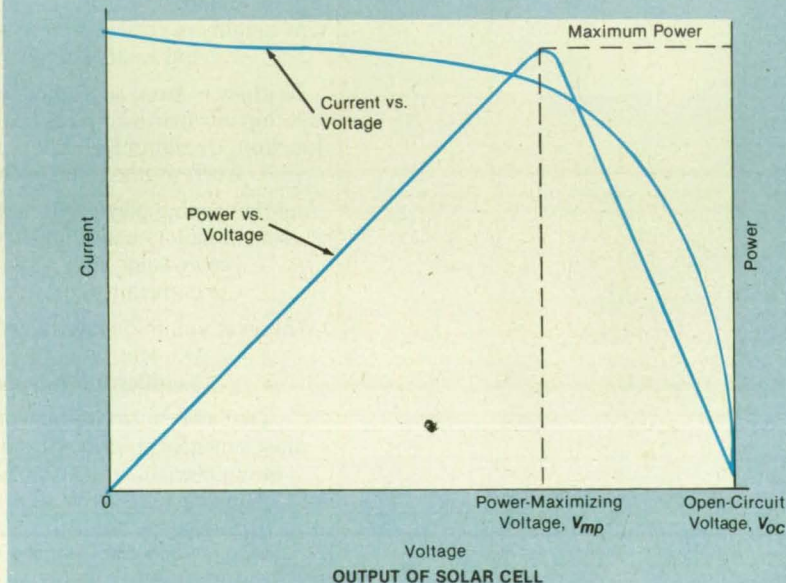
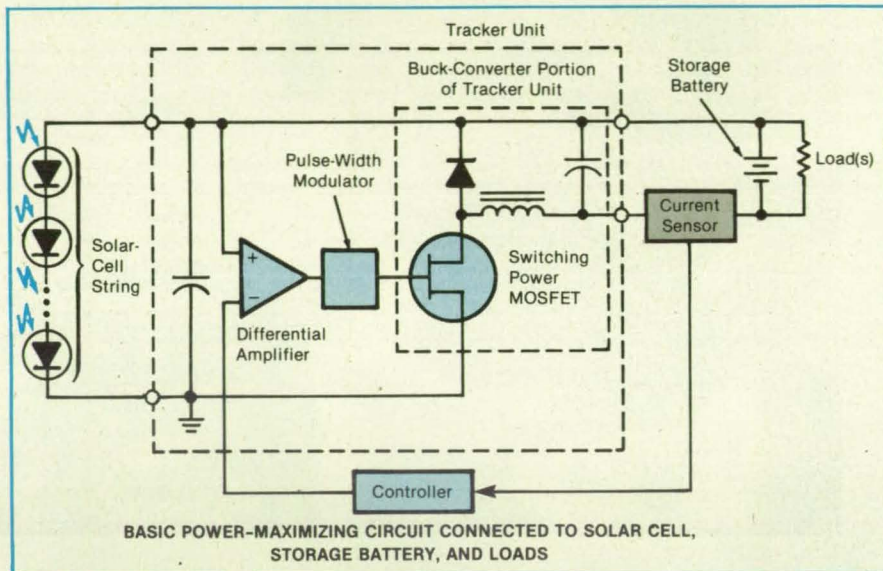


Figure 1. The **Solar-Cell Voltage** at the power-input terminals of the tracker unit is adjusted repeatedly to maximize the current measured by the sensor, thereby maximizing the power delivered to the storage battery and load(s).

rent reading becomes the new nominal operating point during the next cycle. Thus, the controller repeatedly adjusts the cell voltage in small increments, always striving to select the current-maximizing voltage as the nominal operating point.

As shown in Figure 2, the concept can be extended to an array of multiple solar cell strings. Each cell is connected to a separate tracker unit, and the power

outputs of all the tracker units are fed in parallel to the storage battery and load(s). The controller provides a separate control voltage to each tracker unit, adjusting each one in turn to the nominal operating point that maximizes the total current measured by the sensor. In an alternative version, the power output of each tracker is monitored by a separate current sensor, which provides better current resolution

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and greater sensitivity to the contribution of each cell to the total delivered current.

In summary, the main points of the invention are: (1) a single controller is used to control and optimize any number of "dumb" tracker units and strings independently; (2) the power is maximized out of the converters rather than into the converters; and (3) because the controller in the system is a microprocessor, changes in the control algorithm can be made easily with no hardware changes.

This work was done by Martin E. Frederick and Joel B. Jermakian of **Goddard Space Flight Center**. For further information, Circle 46 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 22]. Refer to GSC-13450.

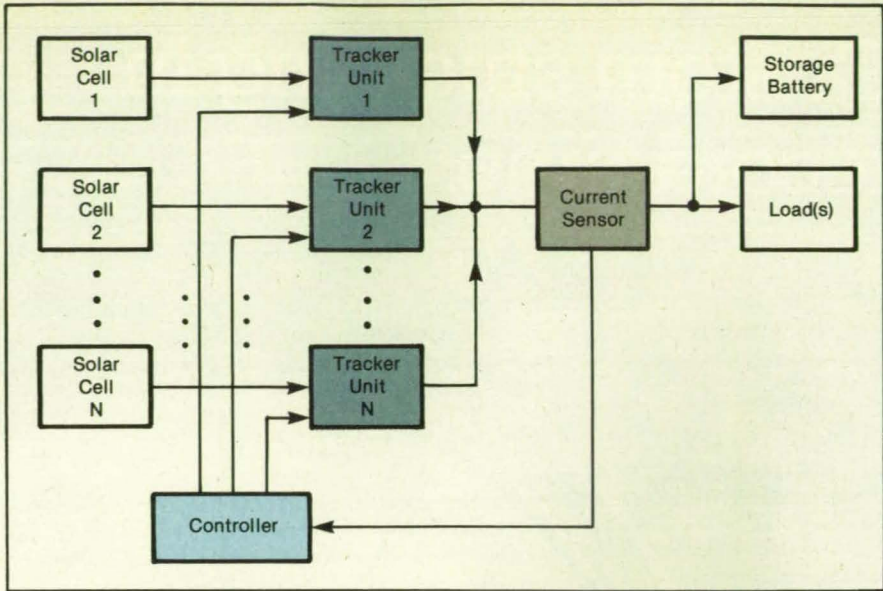


Figure 2. The Contribution of Each Solar Cell in a large array can be maximized by use of a controller operating in conjunction with a separate tracker unit for each battery.

Video-Level Monitor

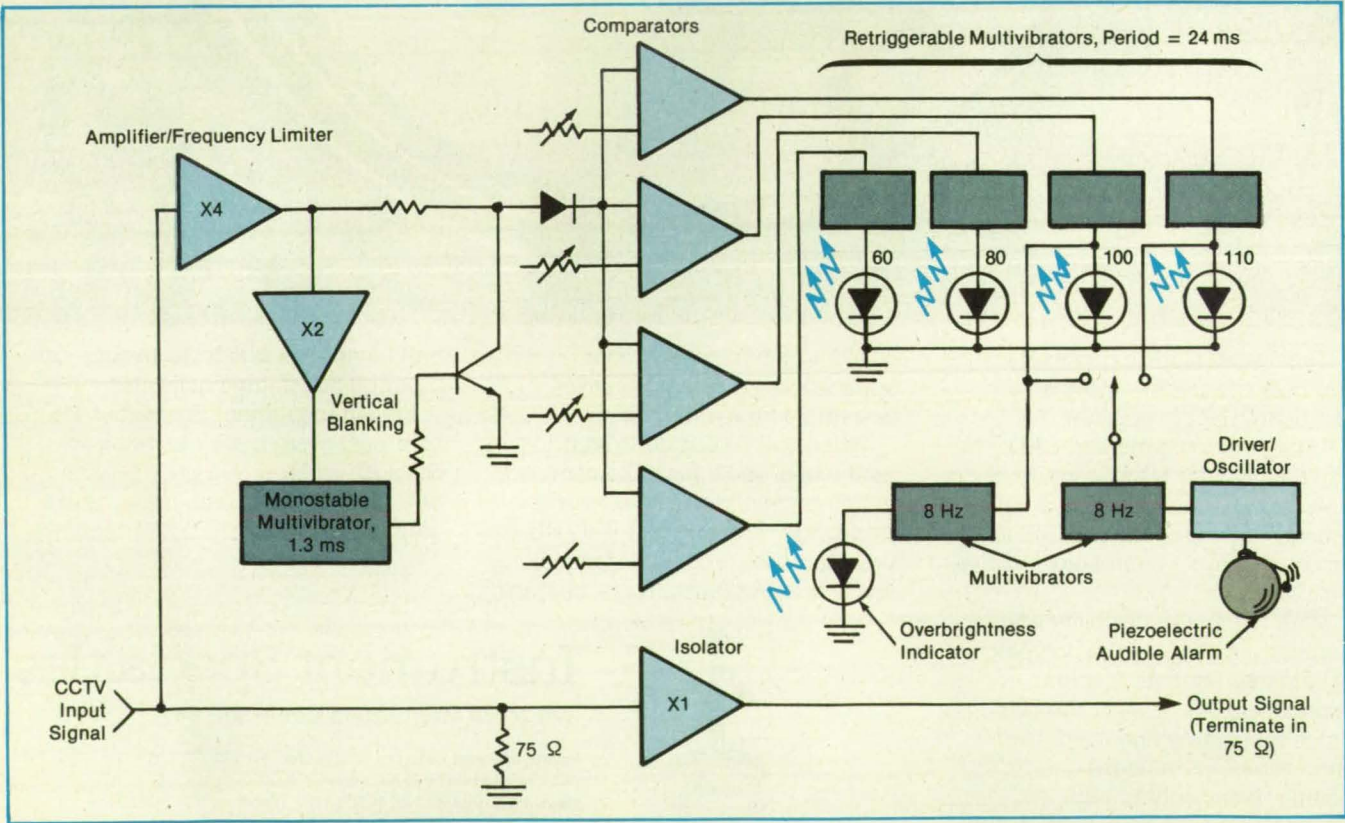
This nonspecific circuit is applicable to most CCTV systems.

Langley Research Center, Hampton, Virginia

When a typical closed-circuit television (CCTV) camera is used to measure the intensity of light, the automatic light-intensity control in the camera must be defeated. These controls use the brightest part of a scene to set the gain, bias, or filter for

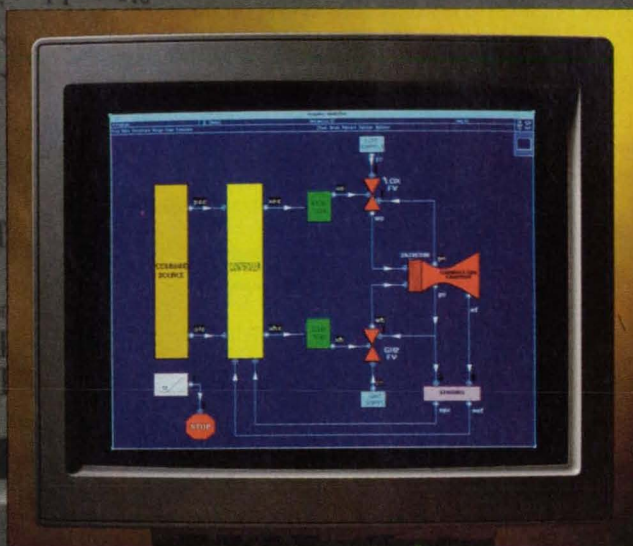
an acceptable level. Some commercially available cameras optionally include level indicators, but each such indicator is specific to a particular camera and not readily adaptable to other systems. Also, a typical video analyzer instrument allows real-

time monitoring of only one small spot or a single horizontal line in the scene and cannot be relied upon to determine overbrightness. Consequently, a video-level monitor was developed to provide full-scene monitoring of the video and to indicate the



The Nonspecific Video-Level Monitoring Circuit eliminates the need for special-purpose level-indicating circuits for different video systems.

CONSTANT csp=1.0
 CONSTANT cswp=0.5
 CONSTANT cshp=600.
 CONSTANT csbp=100.
 CONSTANT cstzpf=0.2
 CONSTANT cspof=1.0
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level of the brightest portion. This circuit was designed to be nonspecific and can be inserted in any closed-circuit camera system that utilizes the RS170 or RS330 synchronization and standard CCTV video levels (+0.7-V video and -0.3-V synchronization).

The video-level monitor (see figure) is inserted between the output video line of the camera and the measurement system or monitor. The monitor indicates the percent video level in IRE units (100 IRE = 0.7 V video) via light-emitting diodes on its front panel. Indicators are provided for 60 percent, 80 percent, 100 percent and 110

percent of full video level. An overbrightness indicator begins to flash at the 100-percent video level. A switch-selectable audible alarm is provided to operate at 100 percent or 110 percent of full video. The system is made of readily available, off-the-shelf components. Development is complete, and several units are in service.

This instrument was developed to satisfy a need when closed-circuit cameras are operated as measuring instruments, but it can be used readily in standard viewing applications. The operator would then have the necessary information to set the

intensity of light entering the camera to a safe level, preventing the premature burn-in of the image tube that would otherwise occur in operation at a high level for a long time.

This work was done by Ray W. Gregory of Langley Research Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14070.

Upper-Bound SEU Rates in Anisotropic Fluxes

Rates are computed from simplified mathematical models of charge-collecting volumes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Upper bounds on rates of single-event upsets (SEU's) in digital integrated circuits and other electronic devices exposed to anisotropic fluxes of energetic ionizing particles can be computed by use of an improved method. Because the method is derived from simplified, worst-case mathematical models of charge-collecting volumes and physical phenomena in the electronic devices, it is not necessary to take account of most of the geometric details of specific devices in computing the bounds that apply to them.

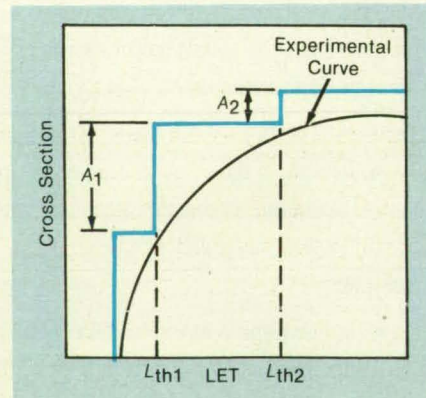
The method allows for the incorporation of SEU cross sections obtained by exposing devices to directed fluxes of heavy ions from particle accelerators. However, meaningful SEU-cross-section data at angles of incidence (with respect to the planes of typical integrated circuits) larger than about 60° are typically unavailable. Where such data are available, they can be incorporated into calculations of SEU rates; where they are unavailable, one assumes the applicable simplified mathematical models and adjusts the unknown param-

eters of the models to obtain maximum SEU rates.

The basic mathematical model of a charge-collecting volume in this method is a circular cylinder. The circular face at one end lies in the plane on the surface of the integrated circuit or other device and has area A . The cylinder has axial length, T , which represents the thickness of the charge-collecting region in the device. The curve of SEU cross section of the device as a function of linear energy transfer (LET) at normal incidence is represented by a staircase function that includes a step function of height A at L_{th} , a threshold value of LET (see figure).

The essence of the method is as follows:

- By use of a computer program called "NIFUR," construct a further simplified mathematical model based on a box that bounds the cylinder and compute, for the given angle of incidence and L_{th} = the given LET value, the sum of the SEU cross sections of particles that traverse the box along four possible trajectories.



The Staircase Curve of the simplified mathematical model bounds the smooth curve of the experimental SEU cross section of a device. The height of each step is the normal-incidence cross section associated with a given charge-collecting volume, and the LET coordinate of the step is the L_{th} of that volume.

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In this computation, an arbitrary value of A is used, and T (which is unknown) is varied to obtain a maximum SEU rate. The effective flux is then defined as this maximum SEU rate divided by A .

- If a tabulation of effective flux vs. LET is available, an estimate of the upper bound on the SEU rate of a device characterized by A and L can be obtained by evaluating the effective flux at $LET = L_{th}$ and multiplying it by A . If such a tabulation is not available, then it can be obtained by use of a computer program called "EFFLUX," which is similar to NIFUR except that the user does not specify L_{th} , A , or T

and the program automatically assigns these values.

- Different tabulations are needed for different orientations of the device in the presence of anisotropic radiation. The upper bounds on SEU rates can then be computed by use of numerical integration to combine cross-section data with effective-flux data.

This work was done by Larry D. Edmonds of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 41 on the TSP Request Card. NPO-18649

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

More About V-Grooved GaAs Solar Cells

Performances of experimental V-grooved cells exceed those of planar cells.

A NASA Technical Memorandum presents some additional information about the experimental devices described in "V-Grooved GaAs Solar Cell" (LEW-14954), *NASA Tech Briefs*, Vol. 15, No. 2, 1991. The use of V-groove and other surface geometries has become increasingly important to increases in the efficiencies of solar cells and tolerance to increased amounts of radiation. The experimental V-groove cells exhibited improved optical coupling and greater short-circuit current than those of control-specimen planar GaAs cells.

The devices and fabrication processes described in the Technical Memorandum are similar to those described in the noted Tech Brief, with one major difference: the thicknesses of the epitaxial base layers of the presently and previously reported devices before etching of the V-grooves were 4 and 4.5 μm , respectively.

The Technical Memorandum includes a comparison of the V-groove cells with the planar cells that were fabricated simultaneously as control specimens. Because of slight differences between the rates of growth and growth conditions on the (111) and (100) crystallographic surfaces, the structures of the two types of cells differ slightly in features other than the mere absence or presence of the grooves. In addition, the more complicated processing steps necessary to fabricate the V-grooves make the grooves more susceptible to imperfections than are the surfaces of the planar cells. Sometimes microlithographic imperfections cause the front metal contacts to form shunt paths that limit the open-circuit voltage. Optimization of the fabrication process has eliminated such imperfections.

This work was done by S. G. Bailey, D. M. Wilt, G. A. Landis, and R. D. Thomas of Lewis Research Center and N. Fatemi of Sverdrup Technology, Inc. Further information may be found in:

NASA TM-102104 [N89-26291], "GaAs Solar Cells With V-Grooved Emitters," and NASA TM-101970 [N89-22177], "A V-Grooved GaAs Solar Cell."

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For More Information Circle No. 252



Prototype Optical Correlator for Robotic Vision System

The known and unknown images are fed in electronically at high speed.

NASA's Jet Propulsion Laboratory, Pasadena, California

An optical correlator and associated electronic circuitry are being developed for use as the vision system of a robotic vehicle. The system is meant to recognize features of landscape by optical correlation between an input image of the scene (the unknown image) viewed by a video camera on the robot and a stored reference image (the known image). The optical configuration of the system is that of the Vander Lugt correlator, in which the Fourier transform of the scene is formed in coherent light and spatially modulated by a hologram of the reference image to obtain the correlation.

The figure shows the major optical components and some of the electronic components of the prototype optical-correlator system. The unknown image is fed from the video camera through a video display and fiber-optic faceplate to liquid-crystal light valve 1, which is thereby made to act as a reflective spatial light modulator. This modulator is illuminated by collimated light from a helium/neon laser, and so the light reflected from it is essentially a collimated beam of coherent light spatially modulated by the unknown image. The reflected beam

then passes through Fourier-transform lenses and beam-splitter cube 2 to liquid-crystal light valve 2.

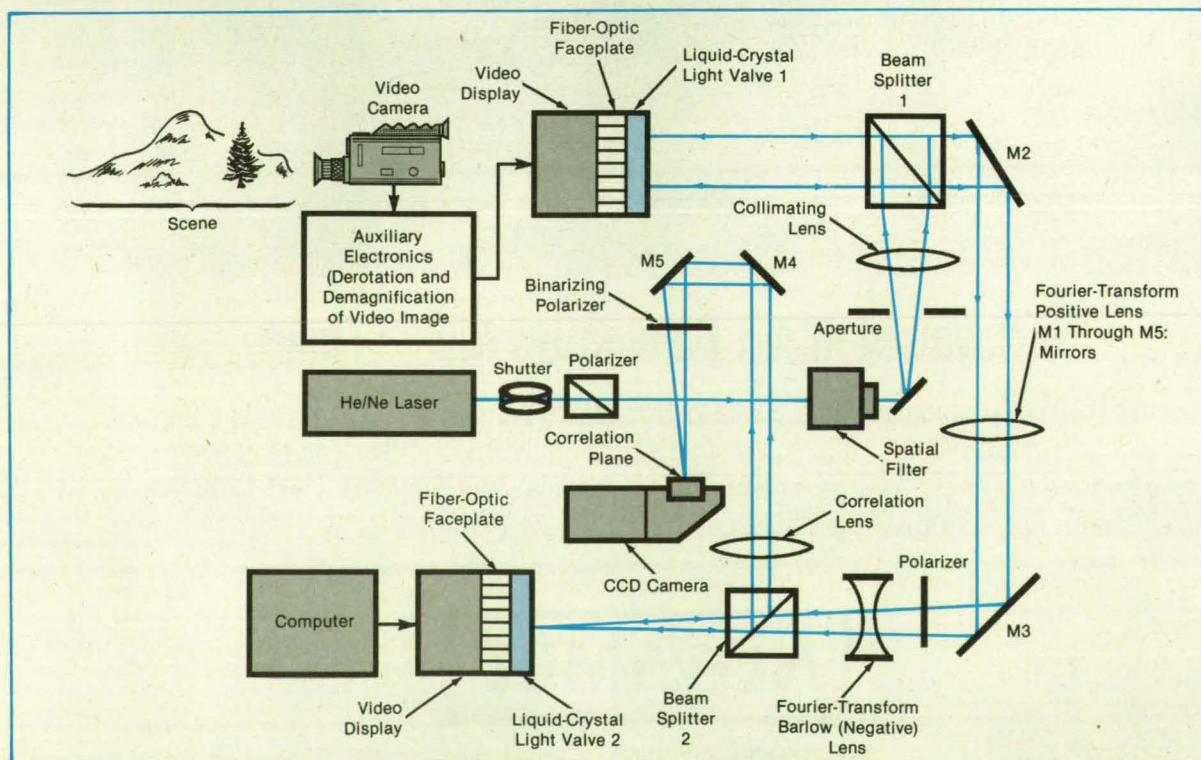
At the same time, a computer generates a binary version of the Fourier transform of the reference image and feeds it through a video display and fiber-optic faceplate to liquid-crystal light valve 2, which also acts as a spatial light modulator. Thus, the spatial pattern of the light reflected from liquid-crystal light valve 2 is a product of the Fourier transform of the unknown image and a binary phase-only filter that approximates the Fourier transform of the known image. This reflected light is polarized and is reflected by beam splitter 2 into the correlation arm of the apparatus. The beam passes through the correlation lens, then through a binarizing polarizer (which increases the contrast between light and dark areas). The correlation image is then focused into a charge-coupled-device camera.

A Vander Lugt correlator generates a correlation peak (a bright spot in the correlation image) at the location of the recognized object, but only if the size and orientation of the object in the input image are

equivalent to those represented in the Fourier transform of the reference image. In this system, auxiliary electronics are used to derotate and demagnify the video image of the scene if the image as produced by the video camera is rotated and magnified with respect to the input image.

The use of binary phase-only filters enables the storage of reference-image data in relatively small electronic memories, because only a "0" or a "1" is stored for each picture element. The sizes of such memories can be reduced further because the higher spatial frequencies have been found not to contain much information and, as a result, it suffices to use only the central third of the filter frame. The combination of the small memory requirement and the video rate of recall results in a correlator that can rapidly test the correlation of an unknown image with a large number of reference images.

This work was done by Marija S. Scholl of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 1 on the TSP Request Card.
NPO-18451



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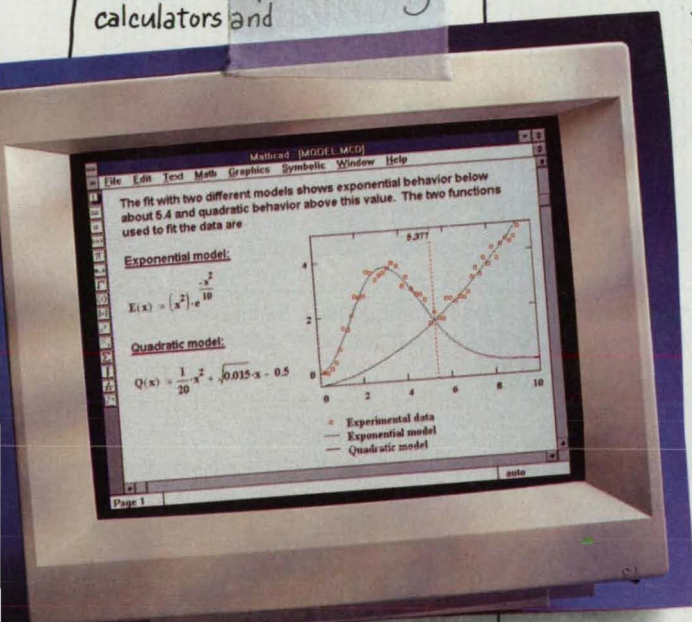
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For More Information Circle No. 679

Bar-Chart-Monitor System for Wind Tunnels

A real-time, vertical-bar display alerts operators to dangerous or otherwise significant conditions.

Ames Research Center, Moffett Field, California

A real-time monitor system that provides bar-chart displays of significant operating parameters has been developed for the National Full-Scale Aerodynamic Complex at Ames Research Center. The system is designed (1) to gather and process sensory data on the operating conditions of wind tunnels and models and (2) to display the data for test engineers and technicians concerned with safety and with validation of the operating conditions. The bar-chart video monitor displays data in as many as 50 channels at a maximum update rate of 2 Hz in a format that facilitates quick interpretation (see Figure 1).

The bar-chart monitor accepts both real-time analog inputs and real-time digitized inputs in the form of pulse-code modulation. In addition, it accepts recorded pulse-code-modulated digitized inputs (see Figure 2). Signals from sensors in a model and wind tunnel are first conditioned; e.g., by amplification, filtering, and parallel-resistor calibration. The resulting conditioned analog signals are then distributed variously to monitoring instruments in a control room, to the bar-chart monitor, and/or to a kernel subsystem. The kernel subsystem digitizes the affected analog signals and processes them into pulse-code modulation for transmission to the bar-chart monitor or to the pulse-code-modulation recorder.

The monitoring technician can easily program the bar-chart monitor from an interactive display/keyboard. The selections include which input channel(s) to display, offset, slope, algorithm, low and high alarm set points, and update rate. The algorithm mentioned in the preceding sentence is one that is selected to process the input in question for representation as an average, maximum, minimum, root-mean-square, or half-peak-to-peak value; or as an x-y vector of the minimum, maximum, or half-peak-to-peak values of any two channels. Depending on the display-update rate, all the displayed values except the average and root-mean-square can be programmed to represent the last 0.5 or 2.0 seconds of data. The average and root-mean-square values represent the last 10 seconds of data.

The bar-chart monitor system has proved valuable in "quick-look" monitoring of stresses in wind-tunnel test models of advanced air and ground vehicles. The system has alerted test crews to potential problems by providing indications of concentrations of stresses in blades, buildups of heat in motor transmissions, aerodynamic stresses in wind-tunnel vanes, and buckling of a column caused

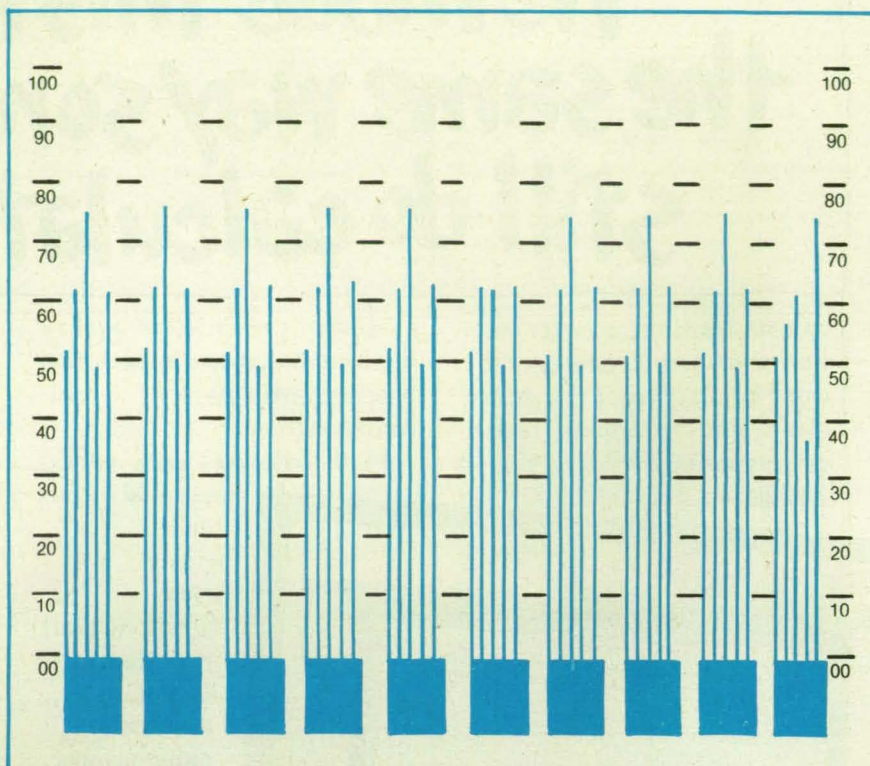


Figure 1. The **Bar-Chart Display** on a video monitor enables a technician to determine, almost at a glance, whether any of 50 operating parameters is outside its proper or safe range.

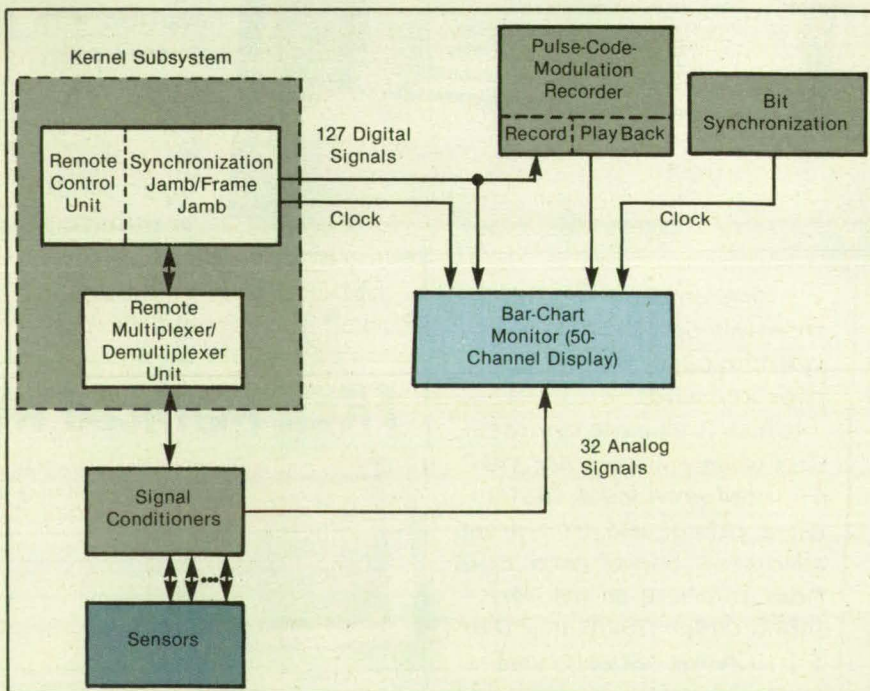


Figure 2. The **Bar-Chart-Monitor System** includes equipment that processes and records sensory data and prepares them for display in the format of Figure 1.

by generation of vortices by a model.
This work was done by Oscar Jung of
Ames Research Center. For further in-

formation, Circle 29 on the TSP Request
Card.
ARC-12867

Optoelectronic Inner-Product Neural Associative Memory

The memory space can be smaller than it is in an outer-product associative memory.

NASA's Jet Propulsion Laboratory,
Pasadena, California

An experimental optoelectronic apparatus acts as an artificial neural network that performs associative recall of binary images. The recall process is an iterative one that involves the optical computation of inner products between a binary input vector and one or more reference binary vectors in memory. The inner-product method requires far less memory space (and, therefore, a smaller and less complicated apparatus) than does the matrix-vector method, which involves precomputation and storage of a matrix that is the sum of the outer products of the reference binary vectors.

"Binary vectors" and "images" are used here somewhat loosely and interchangeably: Each picture element represents a component of a binary vector and, in principle, is either bright (binary level 1) or dark (binary level 0). Thus, a rectangular image composed of $n \times n$ black and white picture elements represents an n^2 -dimensional binary vector.

The following are the steps of the recall process:

1. Compute the inner product between the input vector \mathbf{V} and each of the reference vectors \mathbf{V}_i . The result is a scalar α_i .
2. Compute the sum, \mathbf{Z} , of reference vectors weighted by the inner products:

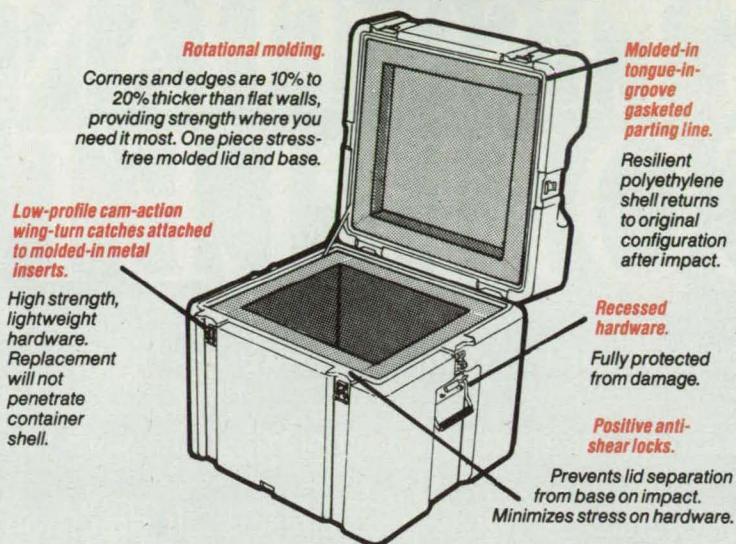
$$\mathbf{Z} = \sum_{i=1}^M \alpha_i \mathbf{V}_i$$

where m = the number of reference vectors and preferably $m \ll n^2$.

3. Process \mathbf{Z} by use of a threshold operator, T_θ : $\mathbf{V}^* = T_\theta(\mathbf{Z})$
4. Substitute \mathbf{V}^* for the input vector in step 1, and repeat the whole process as many times as necessary to make \mathbf{V}^* converge to one of the reference vectors.

An example of the apparatus is shown schematically in the figure. The input image is applied to a liquid-crystal television spatial light modulator, denoted as LCTV 1, which is illuminated by a collimated laser beam. The image is Fourier-transformed by lens 2 and spatially filtered by two pinholes to pass the ± 1 orders of the images diffracted by the inherent grid patterns of LCTV 1. The passed ± 1 orders are reimaged by lens 3 and multiplied by the reference images stored in a transparency

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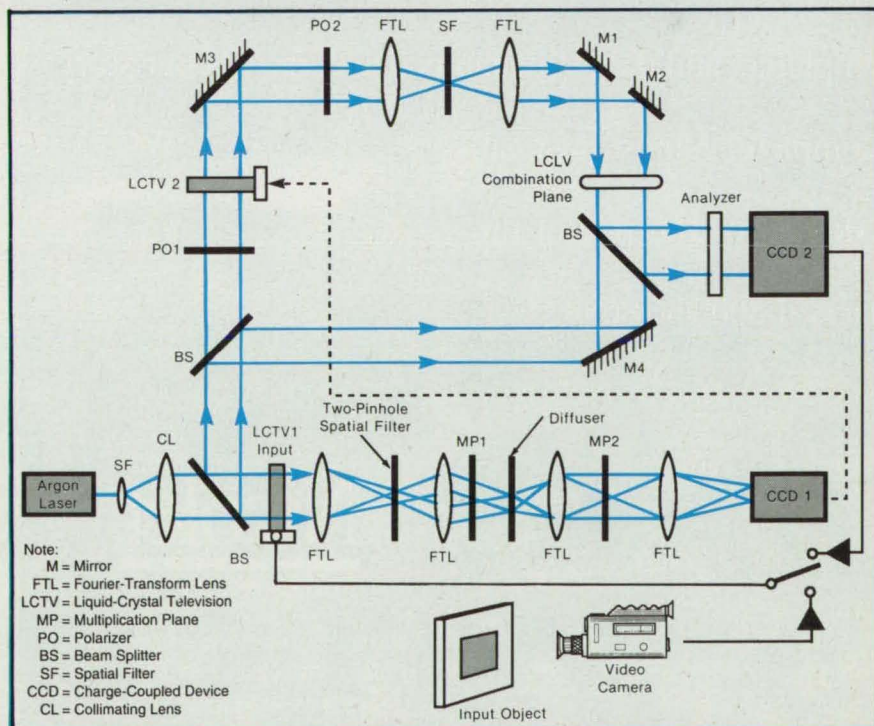
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placed at multiplication plane 1.

The multiplied images are focused on to a fine-grain diffuser. The brightnesses of the light spots on the diffuser represent

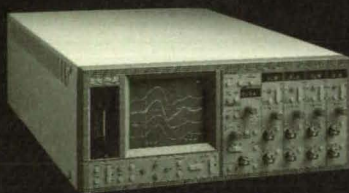
the inner products between the input image or vector and the reference images or vectors. The function of the diffuser is to create uniform distributions of light pro-



This **Experimental Apparatus** exemplifies the operating of an associative-recall procedure via optical computation of inner products between binary vectors, the components of which are represented by bright and dark areas in images.

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portional to the inner products. The uniformly distributed light patterns are then used to weigh (illuminate) the same set of reference vectors (images) that are stored in a transparency at multiplication plane 2.

The weighted vectors are imaged onto a charge-coupled-device video camera, denoted as CCD 1, from whence they are transmitted to and displayed on LCTV 2. To enhance the contrast of the images on LCTV 2, these images are Fourier-transformed and processed through a pinhole spatial filter. The images with enhanced contrast are then reflected by mirrors 1 and 2 into superposition on the writing side of a liquid-crystal light valve (LCLV), which serves the dual function of an optical summing and thresholding device.

The thresholded, summed vector can be read from the output side of the LCLV and picked up through an analyzer by CCD 2. The output can then be applied, as the modified input vector V^* , to LCTV 1.

This work was done by Hua-Kuang Liu of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 94 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 22]. Refer to NPO-18491.

Phase Detector for Rectangular Waveforms

The circuit "coasts" in the absence of a reference signal.
*Lyndon B. Johnson Space
Center, Houston, Texas*

A phase detector for use with phase-locked-loops, servocontrol, and other electronic circuits has been designed to avoid the disadvantages of such other phase detectors as exclusive-OR and edge-locking detectors with memory. The new detector can be used with both intermittent and continuous input signals. Its only major disadvantage is that it would not be particularly useful where the signal-to-noise ratio is low.

The phase detector includes two differentiators, a flip-flop circuit, two current sources (which would normally be equal), and a charge-accumulating capacitor (see figure). A reference signal turns current source 1 on, then off, when it goes high, then low, respectively. The reference signal is also fed through a differentiator to the set (S) input of the flip-flop; when the reference signal goes high, the Q output of the flip-flop turns on current source 2.

NASA Tech Briefs, March 1993

A feedback signal is fed through the other differentiator to the reset (R) input of the flip-flop; when the feedback signal goes high, the Q output of the flip-flop turns off current source 2. If the edges of the reference and feedback waveforms are aligned and 180° out of phase with each other, then both current sources are turned off simultaneously. If the current sources are equal in magnitude, then there is no net change in the charge on the capacitor, and its voltage remains constant. This is the condition when the phases of the two signals are in lock.

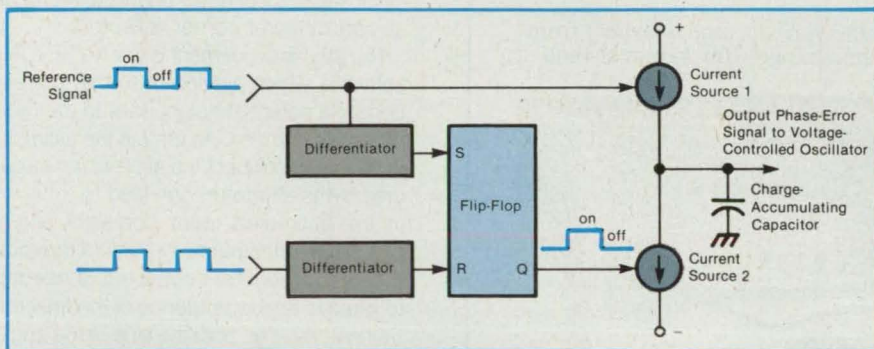
If the two current sources are equal in magnitude but are not turned off simultaneously, then depending on which one is turned off last, there is a net increase or decrease of charge on the capacitor, with consequent change in the voltage across it. This voltage is the phase-error (control) signal, which is fed to the voltage-controlled oscillator to move the phases back toward lock.

This phase-detector circuit offers several advantages: The reference signal can be continuous, a burst of a few pulses, or even

a single pulse (one per measurement period). The duty cycles of the reference and feedback signals are not particularly important, although the duty cycle of the reference signal controls the phase at lock. If the reference signal is interrupted, the circuit "coasts" in the sense that the output phase-error signal does not change until the reference returns. This feature is particularly useful if the reference is a burst of the National Television System Committee or phase-alteration-line (West German television system) type, wherein the bursts are turned off during the vertical-synchronization signal.

The circuit generates no steady-state output waveform at lock, unlike exclusive-OR detectors. This makes filtering easier. The phase at lock can be adjusted by varying the magnitude of one of the current sources or by changing the duty cycle of the reference signal.

This work was done by Robert A. Dischert and James M. Walter of David Sarnoff Research Center for Johnson Space Center. No further documentation is available. MSC-21547



This **Phase Detector** operates with a continuous or intermittent reference signal and "coasts" when the reference signal is absent.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Performance of the Split-Symbol Moments Estimator

The SSME performs poorly with fewer than 6 samples per symbol.

A report presents an analysis of the performance of the Split-Symbol Moments Estimator (SSME) algorithm. The SSME is designed to estimate the symbol signal-to-noise ratio of a radio signal that is modulated by binary data pulses of period T and received in the presence of additive white Gaussian noise. The incoming signal and noise are first filtered, then sampled $N_s = T/T_s$ times per symbol period. The samples are summed by two accumulators

that operate on alternate half symbol periods. The products of the outputs of the accumulators are averaged to obtain an estimate of the signal power. The sums of both accumulators (in effect, integrals over the full symbol period) are obtained, then squared, then averaged, yielding estimates of the total (signal plus noise) power. These estimates are then processed into estimates of the symbol signal-to-noise ratio.

If the data rate is sufficiently high (or, equivalently, if the sampling period T_s is a sufficiently large fraction of T , the sampling rate $1/T_s$ is sufficiently low, or the frequency width of the reception channel is limited), then the estimate produced by the SSME is expected to diverge from the true value. This study focuses on the performance of the SSME in a case in which the frequency width is limited by a digital filter and inter-symbol interference is thereby generated. Closed-form equations that characterize the relationship between the estimated and true symbol signal-to-noise ratios are derived. These equations can be

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used to predict the expected values and variances of the estimates for any combination of data rate, frequency width of the channel, and symbol signal-to-noise ratio.

These equations are validated by applying them to specific examples and comparing their predictions with numerical results of digital simulations. It is shown that the SSME performs well when $N_s > 6$, but poorly with $N_s \leq 6$ because of a high correlation among noise samples of the same symbol.

This work was done by Biren N. Shah and Sami M. Hinedi of Caltech for NASA's Jet Propulsion Laboratory. To obtain a

copy of the report, "Performance of the Split-Symbol Moments Estimator in the Presence of Inter-Symbol Interference," Circle 103 on the TSP Request Card. NPO-18570

Calibration of NASA/JPL DC-8 SAR Data

Recent improvements in experimental conditions and processing of data are described.

A report describes recent improvements

in the calibration of data gathered by a polarimetric synthetic-aperture-radar (SAR) system operated by NASA's Jet Propulsion Laboratory. The radar equipment, mounted in a DC-8 airplane, operates in a three-frequency, quad-polarization mode in the L, C, and P bands with 20-MHz bandwidth and 10- μ s pulse duration.

The first improvement was relocation of the calibration site from Goldstone to Rosamond dry lakebed near Edwards Air Force Base in California. An array of 15 trihedral corner reflectors (which are used for calibration) spans the dry lakebed, which is about 8 km square and encompasses the entire radar swath. The new calibration site is better because it is larger, has a very low radar cross section at all three frequencies, and is situated in a flat region.

The second improvement was the JPL POLCAL software, which provides full polarimetric and radiometric correction of the standard data products of the radar system. [These products are supplied in Stokes-matrix (compressed) format.] The POLCAL software processes calibration data from radar sightings of a few bright (in the radar sense) trihedral corner reflectors.

The third improvement is the ANTENCAL software, which provides a further correction for a potential height error in the radiometric correction. An error in the estimate of the mean height of the airplane (as measured by its altimeter) can lead to an error in the estimated radar boresight angle, which is a principal parameter in the radiometric correction because it is needed to remove the dependence of the final numerical result on both the sine of the angle of incidence and the angular pattern of the beams transmitted and received by the radar antenna. An error of this type can occur, for example, when the airplane flies over a mountain range while imaging the valley below. Of course, this problem does not arise during flight over largely flat areas. If the true mean height of the airplane can be determined for a particular scene, ANTENCAL enables the user to reapply the appropriate radiometric correction to the data.

The last section of the report presents an analysis of calibration performance over a number of sites during the years 1989 and 1990. It concludes, from this analysis, that the system is sufficiently stable to enable calibration of the standard data products without having to place trihedral corner reflectors or other calibration devices in the scene to be scanned.

This work was done by Anthony Freeman, Yuhshyen Shen, Jakob J. van Zyl, and Jeffrey D. Klein of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Calibration of NASA/JPL DC-8 SAR Data," Circle 10 on the TSP Request Card. NPO-18566

Dynamic Signal Analysis with SRS FFT Spectrum Analyzers

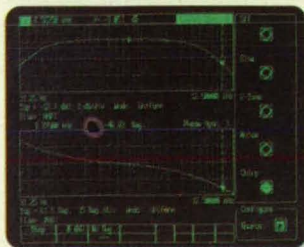
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Request Form (page 99)

All-in-One Handheld Meters for High Precision Calibration of Thermocouple, RTD, Thermistor and Ohm Signals



The new OMEGA CL20 Series high precision handheld calibration/thermometers operate accurately in the field or lab, while offering many functions that translate into cost-effective, increased productivity and long-lasting reliability and versatility. Various models are available for thermocouple, thermocouple and RTD or thermistor applications. Two units also feature a ramp output between two user entered limits.

OMEGA Engineering, Inc.

One Omega Drive, P.O. Box 4047, Stamford, CT 06907

Tel: 203-359-1660

For More Information Circle No. 300

OMEGAsmart™ Temperature Transmitters

The TX62 and TX64 OMEGAsmart temperature transmitters combine the best features of conventional analog transmitters with the advances of digital technology. These TX60 Series transmitters provide unmatched accuracy in their class, with NIST traceable calibration guaranteed for two years and linearized and scalable 4-20 mA output. RS-232 communication capabilities are available on the TX62.



OMEGA Engineering, Inc.

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For More Information Circle No. 301

New Feature Packed, Portable Hybrid Recorder



OMEGA's new RD3750 Series features high speed scanning; ten-color trend recording; datalogging; thermocouple, RTD and voltage inputs; easy-to-carry, lightweight design and an optional memory card for convenient data storage. This versatile recorder is simple to operate and capable of high-speed scanning of 20 points/2 sec and high-speed recording of 50 points/2 sec (up to 30 computed points).

OMEGA Engineering, Inc.

One Omega Drive, P.O. Box 4047, Stamford, CT 06907

Tel: 203-359-1660

For More Information Circle No. 302

New Intrinsic Safety Barriers and Solid State Relays for Hazardous Environments



OMEGA Engineering is pleased to announce a new line of FM, UL, and CSA approved intrinsic safety barriers. The new SBC Series barriers include single and dual channel zone barriers and solid state relays. They are designed to provide protection from fire or explosion when connected to approved field devices, such as flow, level, and pressure switches.

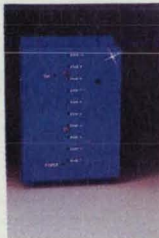
OMEGA Engineering, Inc.

One Omega Drive, P.O. Box 4047, Stamford, CT 06907

Tel: 203-359-1660

For More Information Circle No. 303

New Proportional, Progressive Microprocessor-Based Sequencer from OMEGALUX



The new OMEGALUX SEQ1 Series microprocessor-based sequencer provides pilot duty temperature control for multi-stage electric heating and cooling equipment. This proportional, progressive sequencer with 4 to 20 mA input can provide up to 20 stages of control and has a high ambient rating.

OMEGA Engineering, Inc.

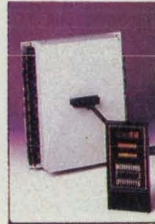
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Tel: 203-359-1660

For More Information Circle No. 304

New! Multi-Loop PID Temperature/Process Controller - Takes The Place of 10 Controllers

The CN3390 series multi-loop PID Temperature/Process controller features 10 PID control loops with auto-tuning, universal sensor inputs and plug-in output modules. Its optical isolation of inputs, outputs and digital communications eliminate ground loops, making it tolerant of noisy industrial environments.



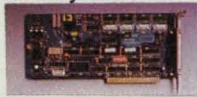
OMEGA Engineering, Inc.

One Omega Drive, P.O. Box 4047, Stamford, CT 06907

Tel: 203-359-1660

For More Information Circle No. 305

New High-Precision DAS-TEMP Board Communicates Multiple Functions Directly to Sensors



OMEGA's new DAS-TEMP board offers high-precision measurement of 32 temperature inputs in one low-cost board. It will directly read the industry standard AD592 current source sensors with a resolution of 0.1°C. Capable of measuring accurately up to 200 samples a second, the board can be used for precise temperature measurement within the range of -25° to 10°C.

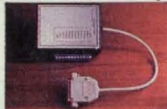
OMEGA Engineering, Inc.

One Omega Drive, P.O. Box 4047, Stamford, CT 06907

Tel: 203-359-1660

For More Information Circle No. 306

User-Friendly DVT-208 Serial Interface Is a New, Low-Cost and Compact System for IBM and Compatible PCs



OMEGA's new leading-edge serial interface for IBM and compatible PCs is the DVT-208. This compact, RS-232 based data acquisition system easily plugs into the computer's serial port for quick-and-easy set-up. The DVT-208 supports data collection from eight signals in the ± 5V range, with 12-bit resolution.

OMEGA Engineering, Inc.

One Omega Drive, P.O. Box 4047, Stamford, CT 06907

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For More Information Circle No. 307



OMEGA's New 1993 Data Acquisition & Control Buyers' Guide™

OMEGA Engineering announces the availability of the 1993 Data Acquisition & Control Buyers' Guide™. This new catalog features hundreds of products for computer-based data acquisition and control. The 1993 Data Acquisition & Control Buyers' Guide™ includes a variety of plug-in boards, software, counters, timers, converters, PC instrumentation, communications equipment, motion controllers, signal conditioners and much more.

OMEGA Engineering, Inc.

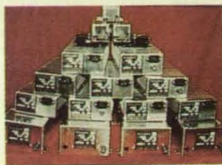
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For More Information Circle No. 433

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For More Information Circle No. 319
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includes information on basic electrical and mechanical theory, safety, motor types, dynamic braking, feedback devices and much more. To order your copy, send a check or money order for \$10 (\$11 outside USA) to:

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Attn: Marketing Communications

For More Information Circle No. 438

DISPLAY LITERATURE

This 24 page catalog contains technical information, illustrations, specifications, and functional descriptions for indoor and outdoor displays as well as custom design services. LXD displays are manufactured in the USA to the highest standards of quality and reliability.



LXD INC.

Cleveland, OH, 216-786-8710

For More Information Circle No. 439

NEW POLYURETHANE FILM & SHEET DESIGN GUIDE AVAILABLE FROM JPS ELASTOMERICS



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performance applications, and illustrates the technical assistance available from JPS Elastomerics.

JPS Elastomerics Corp.

Urethane Products Division, 395 Pleasant Street,
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For More Information Circle No. 440



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Ring Feder Corp.

For More Information Circle No. 443



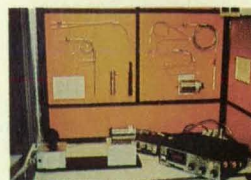
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For More Information Circle No. 321



FIBER INSULATED HEATERS

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RTD'S

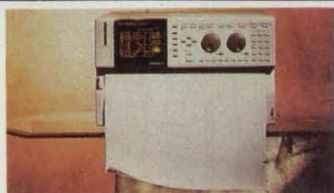
The ThermoCal Model 18 is the first temperature sensor calibrator that has both a COOL Source and a HEAT Source in one package. This is a significant advantage because temperature sensors are most often treated at 0°C (32°F) and at an elevated temperature. Range: -25°C (-13°F) to 650°C (1202°F).

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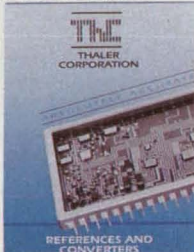
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For More Information Circle No. 326

A/D CONVERTERS AND VOLTAGE REFERENCES

The new 152 page catalog from Thaler Corporation features the industry's most accurate Analog to Digital Converters and Voltage References. New products include a 24 Bit A/D Converter (ADC 150) and hermetic surface mount precision references (VRE200 Series).



THALER CORPORATION

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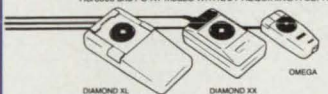
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For More Information Circle No. 330



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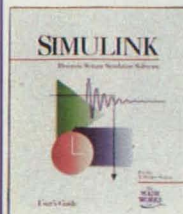
SYNTEX RUBBER CORPORATION

938 Crescent Avenue, Bridgeport, CT 06607

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Rustrak Instruments

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or call 800-332-3202.

For More Information Circle No. 333

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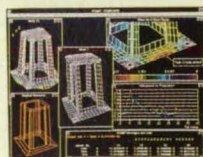
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P.O. Box 264, Harleysville, PA 19438
Phone: (215)256-1829, FAX: (215)256-6913

For More Information Circle No. 342

FIBER OPTIC SENSORS

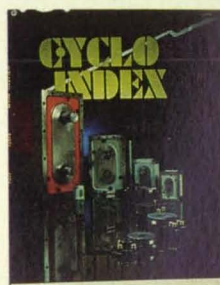
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Pressure Systems

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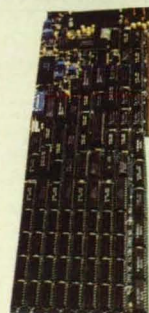
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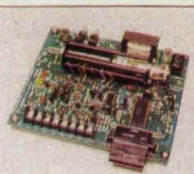
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DESIGN ENGINEERING PRODUCT SHOWCASE

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Phone: (510) 483-8770

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See us At NDES Booth #3736



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Dia-Nielsen USA, Inc.

For More Information Circle No. 347

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The Datagraf Computer Image Recorder is an analog film recorder that addresses the requirements of anyone that needs a photographic record of a computer generated image. Four cameraback options, ranging from 35 mm to 8X10 inch are available. Call (800)538-9231 for information.

Datagraf, Inc.

For More Information Circle No. 348

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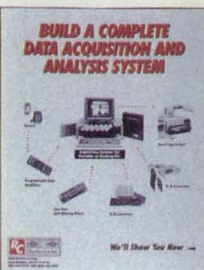
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For More Information Circle No. 315

MICROSCOPES FOR MATERIAL SCIENCES

Microscope product line brochure details upright, inverted, stereo and laser scan microscopes; microscope cameras; microscope photometers; microtomes. All transmitted and reflected light techniques for material sciences and microelectronics inspection can be accommodated. Advantages of Zeiss ICS infinity optics are discussed.



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For More Information Circle No. 351



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The PAPST motor system is a product line of electronically commutated internal and external rotor motors with corresponding electronic components. The line is extended by a series of gear motors. The modular construction of the system ensures individual adaptation to almost any drive problem. The basic elements consist of two different motor lines in the torque

range up to 4.7 Nm as well as electronics with appropriate power rating. The individual components of this product family represent the consequential application of the most advanced technology in electronically commutated drives.

Control Technology Systems, Inc.

For More Information Circle No. 352



BASF CORPORATION PLASTIC MATERIALS

BASF Plastic Materials will show an innovative concept in gasoline dispensing nozzle design. The nozzle does not have the cumbersome corrugated cover around the nozzle spout, making it very easy to use. The lightweight nozzle is smaller and more sleek, thus easier to grip, than standard units. The nozzle uses Ultramid® nylon, Ultraform® acetal and Ultradur® PBT polyester resins from BASF Plastic Materials and BASF's Elastollan® thermoplastic polyurethane. Numerous other new applications for BASF's materials in automotive, consumer products, power tools, electrical/electronic, industrial components, medical, packaging and toys/sporting goods will be shown.

BASF Corporation

For More Information Circle No. 353
See Us At NDES Booth No. 1413

BALZERS TOOL COATING INC.

WEAR RESISTANT COATINGS BROCHURE

Balzers' eight page full-color brochure describes the company's capabilities, equipment and facilities for the application of Titanium Nitride, Titanium Carbonitride and Chromium Nitride wear resistant coatings. Balzers coatings are extremely hard (over 80 Rc) with excellent lubricity and have shown dramatic results in extending wear part life in many applications. The brochure also provides information on Balzers' technical research facility.



Balzars Tool Coating Inc.

North Tonawanda, NY 14120

For More Information Circle No. 354
See Us At NDES Booth No. 2319



B92 CATALOG RELEASE

The latest catalog from W.M. Berg, Inc., coincides with Berg's silver anniversary. Founded in 1967, Berg has grown to become a recognized industrial leader of miniature precision mechanical components. A significant number of new items are added as well as expanding previous product lines.

Featuring 50,000 standard components, 80% of which we are able to ship from stock within 24 hours. Available in metric version too: M92.

W.M. Berg, Inc.

For More Information Circle No. 355



POLYMERS & ACRYLIC MONOMERS

A new, 12-page four-color brochure titled "Engineering Polymers and Acrylic Monomers." Included are polymers and monomers family of products, including Rilsan® 11 and 12 polyamides; Rilsan® powder coatings; Pebax® thermo-

plastic elastomer resins; Platanid® and Platherm® hot melt adhesives; Platon® hot melt film; and acrylic monomers. Product description, background, and a sampling of applications are also provided.

Elf Atochem North America, Inc.

For More Information Circle No. 356

DESIGN ENGINEERING PRODUCT SHOWCASE



COMPLETE FILTER ANALYZER

The only commercial instrument available capable of performing Integrity Tests, Pressure Hold Test, Gas Permeability, Liquid Permeability, Bubble Point and Pore Distribution analysis using Windows based software. Tests almost any user supplied shape even under tension or compression. Analytical services available. For details call 607-257-5544. In USA and Canada 1-800-825-5764. FAX:607-257-5629.

Porous Materials, Inc.

83 Brown Road, Bldg. 4, Ithaca, NY 14850.

For More Information Circle No. 357



ANALYTICAL SERVICES - FAST TURNAROUND

Brochure describes the wide range of materials characterization services that are provided by the firm's Analytical Services Division. Among those described in the brochure are surface area, pore and particle size distribution, density, permeability, chemisorption and pressure testing. Also available are instruments for sale or lease. Tel:607-257-5544. Toll Free in USA and CANADA 1-800-825-5764. FAX:607-257-5639.

Porous Materials, Inc.

For More Information Circle No. 358



COMPUTER CONTROLLED VALVES

Brochure describes company's line of remote and computer controlled on-off, metering and servo valves, pressure generators, automated pressure and flow control systems, pressure gauge calibration systems and capability for custom configurations. Pressure range from high vacuum to 60,000 PSI. Tel:607-257-5544 Toll Free in USA and CANADA 1-800-825-5764. FAX:607-257-5639.

Advanced Pressure Products

83 Brown Road, Bldg 4, Ithaca, NY 14850

For More Information Circle No. 359



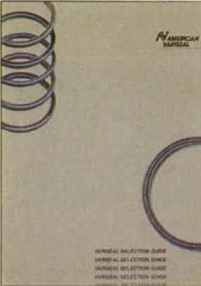
ANVIL'S PC TRAVELER

The ANVIL PC TRAVELER is engineered for transportable PC systems. With over 40 years experience in designing and manufacturing, ANVIL builds cases which add value and functionality to the systems they house. The ANVIL PC TRAVELER provides protection from the hazards of the road, reduced shipping costs and extended system life through protection. ANVIL has designed PC TRAVELER cases for most PC's available today.

Anvil Cases,

A Subsidiary of Zero Corporation

For More Information Circle No. 360



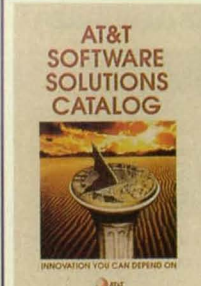
NEW SEAL SELECTION GUIDE

American Variseal announces their new Seal Selection Guide for high performance spring energized seals. This unique eight-page, color manual, which describes Variseal's wide range of products for static, reciprocating and rotary service, utilizes highly functional charts and illustrations. Engineering charts

include seal performance ratings at various pressures, temperatures and speeds. Also included are data on seal materials, gland design, surface finish, standard sizes, custom designs, and technical support. Call 1-800-466-1727 for further information.

American Variseal

For More Information Circle No. 361



SOFTWARE SOLUTIONS CATALOG

New catalog features 38 innovative software packages developed and tested within AT&T. Applications include communications, operations and network management software, development and performance tools, math/stat packages, and more, for various

platforms/systems. Ideal source for remarketers and end users.

AT&T Software Solutions Group

For More Information Circle No. 362



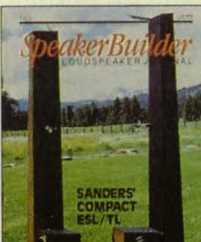
BATTERY POWERED 8-CHANNEL FIELD RECORDER

Astro-Med's portable 8-channel field recorder operable from its internal battery is described in an illustrated 10-page brochure. The lightweight unit, called the Dash 8, features extra-

ordinary capabilities. It offers frequency response to 25 kHz; "on the fly" grid formats; AC and 11-18 VDC operation; on-demand self-calibration; and data capture and playback.

Astro-Med

For More Information Circle No. 363



FREE TRIAL ISSUE

Speaker Builder is a bi-monthly magazine dedicated to the technically competent person who wants better sound. Speaker Builder features loudspeaker projects ranging from simple modifications to construction of the most sophisticated designs available today.

Speaker Builder

PO Box 494, Peterborough, NH 03458-0494
(603)924-9464, FAX:(603)924-9467.

For More Information Circle No. 364

Din Rail Mounted Transducers



Measure either AC voltage or AC current with our new DIN rail mounted transducer. The slim profile allows maximum use of available space. Field selectable analog outputs, recessed terminals for increased safety, and rugged polyamide case make this an ideal transducer for use in enclosures with dimensional constraints. Designed for use in industrial environments and OEM measurement systems. May be used with potential or current transformers and integrated into control systems. Contact Ohio Semitronics, Inc., 1205 Chesapeake Ave., Columbus, OH 43212-2287. Phone: 614-486-9561, Fax:614-486-0743.

Ohio Semitronics

For More Information Circle No. 365

REAL-TIME DIGITAL IMAGE PROCESSOR



The DSP-2000 improves noisy, low contrast images. Memory functions and spot mask provide background subtraction to remove unwanted image artifacts, non-uniform illumination and shading. Features: high resolution, gain control providing grey scale expansion, real-time averaging, integration, edge enhancement, gamma, pseudo or RGB color, RS-232 port and SCSI interface. Catalog available.

Dage-MTI

701 N. Roeske Ave., Michigan City, IN 46360
(219)872-5514,

For More Information Circle No. 366

PROBLEM: Maximum Thermal Performance in a Minimum of Space



SOLUTION: BTU-Block Insulations

Very low thermal conductivity
Variety of forms for temperatures to 1000°C
High compression strength
Ideal when space is limited.
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SCHULLER

For More Information Circle No. 367



Sculptured® Circuits combine the best features of all known technologies: The versatility of wire, the economy of flexible circuits, and the terminating ability of a connector.

Sculptured® Circuits offer you: Versatility: custom length and current carrying capacity; Reliability: each pin in an integral extension of its conductor; Low Unit Cost: easily manufactured, on-time delivery. To learn more about Sculptured® Circuits call or write:

Advanced Circuit Technology, Inc.

118 Northeastern Boulevard, Nashua, NH 03061.
Tel:603-880-6000, FAX:603-880-1785.

For More Information Circle No. 368

DESIGN ENGINEERING PRODUCT SHOWCASE

LINEAR ACTIVE FILTER COMPONENT

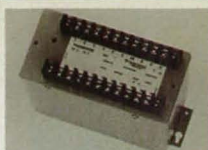


The new D68 linear active filter is compact and low profile while offering -94dB harmonic distortion and a signal-to-noise ratio to 16-bit resolution. A self contained solution, available in several transfer functions from 10Hz to 100kHz. Price: \$115 for 1000+.

Frequency Devices, Inc.

25 Locust Street, Haverhill, MA 01830
(508)374-0761.

For More Information Circle No. 369



MODEL PC20 AC WATT/POWER FACTOR/VOLT-AMPERE TRANSDUCERS

Model PC20 provides three separate isolated output signals proportional to Watts, Power Factor, and Volt-Amperes, from the same current transformers. Power Factor is derived from the ration of true power to apparent power. Accuracy of $\pm 0.25\%$ Watts/Volt-Ampere and ± 0.005 Power Factor is maintained even with distorted or chopped waveforms. Typical applications include power quality and machine performance monitoring. For more information and our free catalog contact:

Ohio Semitronics, Inc.

1205 Chesapeake Ave., Columbus, OH 53212-2287.
Phone: 614-486-9561, Fax: 614-486-0743.

For More Information Circle No. 370



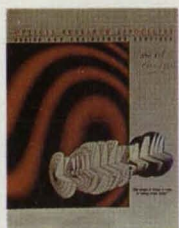
LOW COST CURRENT TRANSDUCER

Designed for use in applications requiring inexpensive current measurements. The Model CTD is insensitive to polarity, accurate and reliable from 50 to 400Hz and easy to install. Choose from self-powered 0 to 1mA, or loop-powered 4 to 20 mA models. For a catalog with more information on this and our complete line of transducers and related equipment contact:

Ohio Semitronics, Inc.

1205 Chesapeake Ave., Columbus, OH 43212-2287.
Tel: 614-486-9561. Fax: 614-486-0743.

For More Information Circle No. 371



ENGINEERING SERVICES

Optical Research Associates, the industry's leading optical design firm, provides world-class engineering solutions across the entire spectrum of optical design. From X-ray wavelengths to the far infrared, from optical systems for consumer and industrial products to highly complex government and military applications, ORA leads the way.

OPTICAL RESEARCH ASSOCIATES

550 North Rosemead Blvd., Pasadena, CA 91107
818-795-9101 (TEL) 818-795-9102 (FAX)

For More Information Circle No. 372



INSTRUMENT TECHNOLOGY, INC.

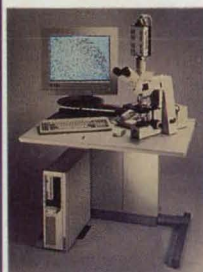
Instrument Technology, Inc. specializes in the design, development and manufacture of Standard Product and Custom Remote Viewing Instruments and Systems for the industrial market. To satisfy requirements, ITI produces high quality Borescopes, Fiberscopes, Videoscopes, Telescopes, Periscopes and Systems. For more information contact:

ITI, P.O. Box 381, Westfield, MA 01086.

Tel: (413) 562-3606.

Fax: (413) 568-9809.

For More Information Circle No. 373



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ProgRes 3012 Camera-Programmable resolution to 2994 x 2320 x 36. Windows and Macintosh environment. ProgRes/ImageManager-Camera & Powerful interactive database, image transmission, and tele-conferencing workstation using standard phone lines.

Roche Image Analysis Systems

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Fax: (510) 827-4342.

For More Information Circle No. 374



GRAPHIC CONTROLS COMPUTER GRAPHIC SUPPLIES

Graphic Controls Computer Graphic Supplies meet or exceed OEM specifications and enhance the accuracy of virtually all of today's CAD output plotters and printers. Full line includes plotter pens and media, electrostatic

media and toner, ink jet media and cartridges, direct imaging thermal media, and more.

Graphic Controls Corp.

For More Information Circle No. 375
See Us At NDES Booth No. 2155

FREE CATALOG

PC Data Acquisition, Control & Test I/O Boards

58-page catalog describes complete line of IBM PC/XT/AT and compatible analog and digital I/O cards; communication interfaces; data acquisition and control software packages and accessories.

ACCES

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Fax: (619) 578-9711

Toll Free (800) 326-1649

For More Information Circle No. 376



Vigra Vgs VME GRAPHICS SERVER



Processor: 33MHz MIPS R3000 compatible w/FP coprocessor.

Resolution: Programmable up to 1380x1024.

Memory: 8Mbyte DRAM, 2Mbyte VRAM, 0.6 Mbyte overlay RAM.

Graphics Interface: X11R5 standard, others available.

I/O: Keyboard, dual serial, sound generator.

Vigra, Inc.,
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For More Information Circle No. 377

RACK MOUNT INDUSTRIAL PC SYSTEM

High Speed Performance at Super Low Price! The ADAC 8100 Series is built with a heavy duty steel case complete with rugged lock-in-place slides for standard 19" mounting. Choice of CPU: 50MHz 486DX, 33MHz 486DX, or 20MHz 386SX, passive 12 Slot AT backplane, 250 watt power supply, and choice of mass storage.



ADAC Corp.

Tel: (800) 648-6589, fax: (617) 938-6553.

For More Information Circle No. 378



MILES ENGINEERING RESINS GUIDE

Brochure presents data on physical properties, grades, features and typical applications for six thermoplastic resins available from the Polymers Division of Miles Inc. Resins include Makroton polycarbonate, Apec high-heat polycarbonate, Makroblend polycarbonate blends, Bayblend polycarbonate/ABS blends, Durethan polyamide 6 and Texin and Desmopan thermoplastic polyurethanes.

Miles Inc.

For More Information Circle No. 379

Shock & Vibration Control



ISOLOSS® Sandwich Mounts

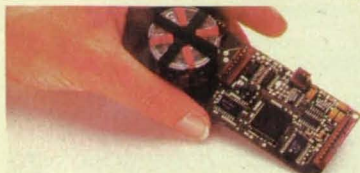
New from E-A-R Specialty Composites, a standard line of 24 metal-bonded isolators features our proprietary, high performance ISOLOSS elastomers. Also available in custom configurations, ISOLOSS Sandwich Mounts control noise, vibration, shock and motion in a wide range of applications.

E-A-R Specialty Composites

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For More Information Circle No. 380
See Us At NDES Booth No. 635

KVH C-100 Compass Engine



Whether your application involves pointing, aiming, or navigation, KVH offers a family of rate, tilt, and directional sensors to meet your needs. The C-100 is a versatile, miniaturized, 0.5° accurate heading sensor which comes with menu driven configuration software and a variety of analog and digital outputs making it an economical solution for your demanding applications.

KVH Industries, Inc.

110 Enterprise Center, Middletown, RI 02840.
Tel:(401)847-3327

For More Information Circle No. 381

SEKAI MINIATURE COLOR CAMERA

BEST OF ALL WORLDS...

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**Ruggedized & Qualified
Miniature, Less than 1" X 1" X 5"
470 Lines of Horizontal Resolution
Low Light 4.5 LUX**

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Ron Burnett.

For More Information Circle No. 384



WORKMANSHIP STANDARDS MANUALS

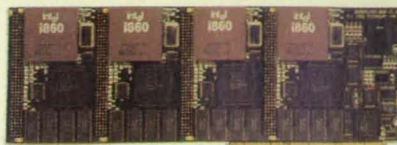
Workmanship Standards were developed by Martin Marietta to use as guidelines in manufacturing electromechanical and electronic systems that perform to exacting government/defense requirements. Photographs and clear instructions provide the individual with a clear definition of

what is required on the production line and in training programs.

Martin Marietta Information Systems

For More Information Circle No. 387

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QuadPuter®-850

The ideal solution for your DSP and general scientific computing needs...From one to eight QuadPuters can be run in EISA BUS machines, using our multi-tasking software, providing an upper limit on PC throughput of 1.6 Giga-flops! Call Tel:(508)-746-7341, Fax:(508)746-4678 for technical information.

Microway

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Tel:(508)-746-7341,
Fax:(508)746-4678.

For More Information Circle No. 382



NOISE CONTROL PRODUCTS

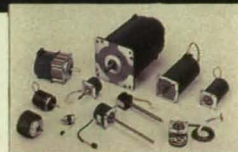
New color brochure describes SONEX and SONEX 1 sound-absorbing materials with patented shapes that control noise better than standard acoustical treatments. Brochure explains basic noise control techniques and presents many forms, sizes, and colors of SONEX products for industrial, office and OEM noise control.

Brochure shows applications and includes information on acoustical performance.

Illbruck

For More Information Circle No. 385

STEP & SYNCHRONOUS MOTORS



SLO-SYN® DC Step Motors in 1.8 degrees full step can be microstepped. Low cost, simple control AC Synchronous Motors provide high torque application alternatives. Special use types include vacuum, high temp, special shaft, gearheads, more.

Superior Electric

Bristol, CT 06010
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For More Information Circle No. 316

ARE YOU STILL TRYING TO MEASURE VERY THIN GAPS THE HARD WAY?



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Capacitac

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For More Information Circle No. 386



WORKMANSHIP STANDARDS MANUALS

Workmanship Standards were developed by Martin Marietta to use as guidelines in manufacturing electromechanical and electronic systems that perform to exacting government/defense requirements. Photographs and clear instructions provide the individual with a clear definition of

what is required on the production line and in training programs.

Martin Marietta Information Systems

For More Information Circle No. 387



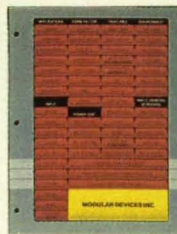
DC Motor Controls

New 48p catalog allows you to select optimum control for sub-sub-fractional to 10 horsepower DC motors, Machine Tools, Motorized Machinery, Positioning, Conveyors, Actuators, Packaged Machinery, Exercise Equipment, XY Tables, Elevators/Levelers, and Theatrical/Stage. Power Ups can customize these controls for your exact requirements.

POWR UPS CORP

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For More Information Circle No. 388



HIGH REL HYBRID/DISCRETE DC-DC CONVERTERS

This new 32p catalog describes a full line of hybrid and discrete DC-DC converters for Space, Military and Industrial application, wide range of DC input voltages, output from 3 VDC (for new IC applications) to 3 Kilovolts, multiple outputs, full EMI filters/other systems type circuitry, Rad Hard versions specified, and custom variations available.

Modular Devices Inc.

One Roned Road, Shirley, NY 11967. Tel:(800)333-POWR; Fax:(516)345-3106.

For More Information Circle No. 389

Free Data Acquisition Software Tool



DAQ Designer is a free software tool that helps determine which hardware and software combinations are best for your PC-based data acquisition system. DAQ Designer will (1) ask questions about your application, (2) analyze your answers to determine your systems needs, and (3) describe what hardware and software you need to develop your data acquisition system.

National Instruments

6504 Bridge Point Parkway, Austin, TX 78730,
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For More Information Circle No. 390



FULLY INTEGRATED AIR BEARING SYSTEMS

NEAT now offers complete "turn-key" air bearing systems to suit a variety of high precision applications. Pictured is a five axis inspection system which utilizes both air bearing and mechanical stages along with rotary and linear brushless servo motors. This custom integrated air bearing based system is one example of the many conformations

NEAT is prepared to design and manufacture for fully automatic positioning applications requiring high speed and ultra-precise positioning accuracy performance.

New England Affiliated Technologies

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1-800-277-1066.

For More Information Circle No. 391



COMPACT CABINET COOLERS

Compact Cabinet Coolers™ keep electronic components in sealed enclosures cool, clean and isolated from contaminants. They last thirty years and require no maintenance. Standard models are NEMA 12. Stainless Steel, NEMA 4, and NEMA 4X models are available.

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For More Information Circle No. 392
See us At NDES Booth No. 3867

DESIGN ENGINEERING PRODUCT SHOWCASE

PRECISION ROLLED THREAD BALL SCREWS



PowerTrac™ Precision Ball Screws are convenient and efficient devices for converting rotary to linear motion with 90% efficiency. Long, predictable life expectancy. Lead error is .001 per foot. Available in sizes from 3/8 to 4".

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For More Information Circle No. 393



MATLAB HIGH-PERFORMANCE NUMERIC COMPUTATIONAL AND VISUALIZATION SOFTWARE

MATLAB is a high-performance, interactive numeric computational and visualization environment that combines hundreds of advanced math and graphics functions with an easy to use and flexible high-level language. The open system architecture enables users to view the pre-packaged functions, customize these as needed, or add new functions. MATLAB application toolboxes extend the power of MATLAB by providing leading-edge algorithms and functions developed by renowned experts in digital signal processing, control system design, neural networks, optimization, and other application areas.

The MathWorks, Inc.

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Tel: 508-653-1415.

For More Information Circle No. 394

PRECISION OPTICS

Acton Research Corp. provides the highest quality coatings, filters and complete mirrors.

- Maximum Reflectance High Power Coatings
- High Efficiency Broadband Reflective Coatings
- Optical Filters (122nm-1064nm)
- Beam-Turning Mirrors
- Single Piece to OEM Quantities



Acton Research Corporation

Tel: 508-263-3584, Fax: 508-263-5086.

For More Information Circle No. 395

AFFORDABLE DEVICE PROGRAMMERS

The PB-10 device programmer is a development tool that everyone can afford! If you need to program EPROMs quickly and easily, you definitely want to check out this programmer. All that the PB-10 requires is an expansion slot in the PC. The two-foot long ribbon cable extends outside the PC to a 40 pin ZIF socket, and the software to operate the unit is included. Priced at \$139.95. Call now for information.

Needham's Electronics
Tel: 916-924-8037, Fax: 916-972-9960

NEEDHAM'S ELECTRONICS

For More Information Circle No. 396



RAPID PROTOTYPING WITH MCP VACUUM CASTING SYSTEM

With the MCP Vacuum Casting System you can produce all the precise copies you require for your product development and testing purposes such as for TV and computer housings, automotive components, household plastic components, etc.

MCP Systems Inc.

For More Information Circle No. 397



AFFORDABLE DEVICE PROGRAMMERS

Do you need device programming support on a limited budget? Our device programmers support a very wide variety of programmable devices and won't hurt your project budget. The EMP-20 is a parallel port-driven programmer which supports EPROMs, EEPROMs, Flash EEPROMs, NOVRAMs, Microcontrollers, and Electrically-Erasable PLDs from every major manufacturer. Priced at \$449.95. Call for more information.

Needham's Electronics
Tel: 916-924-8037, Fax: 916-972-9960

NEEDHAM'S ELECTRONICS

For More Information Circle No. 398

MECHANICAL TESTING LABORATORY

Exclusively devoted to mechanical testing, MarTest has provided testing services for a variety of industries including aerospace, transportation and medical for over 20 years. Extensive facilities and experienced personnel ensure quick turnarounds and accurate, reproducible results. Phone: 513-771-2536, Fax: 513-771-2564.

Mar Test, Inc.

For More Information Circle No. 399

THE BEST SOURCE FOR IEEE-488



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For More Information Circle No. 405



CORROSION SERVICES

Literature describes corrosion testing consulting services. Product-equipment evaluations in corrosive environments; exposure tests in natural, marine and altered environments; evaluating materials performance; SEM and metallographic examinations; environmental-corrosion monitoring; electro-chemical testing;

failure analysis; corrosion training. P.O. Box 656, Wrightsville Beach, NC 28480, Tel: (919) 256-2271, Fax: (919) 256-9816.

LaQUE CENTER FOR CORROSION TECHNOLOGY

For More Information Circle No. 400

ESTIMATING WITH CAD

The COSTIMATOR® system now allows cost estimating of new products using most CAD systems. Estimates are reported to be within 5% of actual costs with this new mouse-driven system. DFM compatible. Easy to use. Fast payback.



Manufacturers Technologies, Inc.

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For More Information Circle No. 401



FREE ISSUE—SCITECH JOURNAL

Call for a free issue of the bimonthly journal of the MacSciTech Users Association. Other benefits: free consultations with Expert Panel, software archives, technical conferences, solution guides, and discounts on CD-ROMs, books, courses, products, and more.

Macintosh Scientific and Technical Users Association

49 Midgely Lane, Worcester, MA 01604.
Tel: 508-755-5242; Fax: 508-795-1636

For More Information Circle No. 402



NEW LEMPCO INDUSTRIES BEARINGS CATALOG

Lempcoloy Bearing Products have been the answer to many design problems involving hard to lubricate bearing surfaces, corrosion and abrasion resistance. The catalog describes the features and technical specifications of Lempcoloy Lube-Free Bearing Products. Available in standard sizes or your custom applications.

Lempco Industries Inc. Bearings Division

For More Information Circle No. 406



JANE'S INTERAVIA SPACE DIRECTORY 1992-93

Comprehensive coverage of the world's space programs and organizations. Designed for the space professional to monitor space developments worldwide, evaluate national and international programs, identify commercial opportunities in the industry and more. Detailed photographs and diagrams and launchers, communications equipment, navigation and the latest developments in space. Featuring names, addresses, phone and fax numbers of top aerospace contractors. Softbound, over 650 pages.

Jane's Information Group, Inc.
For More Information Circle No. 407

LDS 4000 PLUS SCANNER



The LDS 4000 Plus wide format scanner operates at a high speed and scans documents up to 40" wide and 100" long. The scanner is suited for scanning large volumes of drawings and supports DOS and Microsoft Windows 3.1 platforms. The resolution is selectable up to 500 dpi, and the scanner supports over 30 raster file formats.

SUMMAGRAPHICS CORPORATION

Seymour, CT 06483-3907
Tel: 203-881-5400, Fax: 203-881-5367.

For More Information Circle No. 410

XY RECORDER Replaces HP 7004/45



- Form, Fit and Function Replacement
- High Sensitivity and inch or cm calibration
- Calibrated Offset and Time Base
- Standard or High Acceleration Models
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ALLEN DATAGRAPH

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800-258-6360.

For More Information Circle No. 414

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Solder Absorbing Tech. Inc.
For More Information Circle No. 317

NEW TEST & MEASUREMENT CATALOG



Keithley's new 1993-1994 catalog features 240 pages of electronic test and measurement instruments, including DMMs, electrometers, sources, picoammeters, source-measure units, switch systems, LCZ meters, and much more. This valuable reference guide includes product specifications, selector guides, and comprehensive technical data.

Keithley Instruments, Inc.,

28775 Aurora Road, Cleveland, OH 44139
Phone: 800/552-1115, Fax: 216/248-6168.

For More Information Circle No. 408

NEW REFERENCE MEASUREMENT UNIT



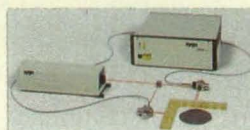
Provides angular position and motion information for guidance, stabilization, control, or simply for test purposes. Contains, in six inches cubed, 3-axis angular position and angular rate information plus BIT and other utilities for guidance and control of "Smart Bombs." Custom units can provide selected position and motion sensors for uses ranging from missiles to automotive testing, and more.

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Tel: 619-565-6631, Fax: 619-565-6873.

For More Information Circle No. 412

NEW DISPLACEMENT MEASURING INTERFEROMETER SYSTEM



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For More Information Circle No. 409

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For More Information Circle No. 413

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For More Information Circle No. 416

OEM PUMP CATALOG



Pump catalog provides dimensional drawings, product features, and performance curves for the standard pump modes available from Gorman-Rupp Industries. Pump designs include Bellows Metering, Centrifugal, Magnetic Drive, Oscillating, Nutating, and Peristaltic Pumps.

GORMAN-RUPP INDUSTRIES

For More Information Circle No. 419

VACUUM GAUGE CONTROLLER REDUCES DOWNTIME



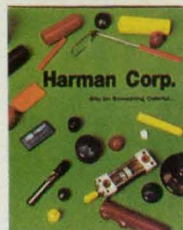
The 307 Vacuum Gauge Controller (VGC) from Granville-Philips is designed to help reduce downtime caused by controller failure in vacuum process applications from atmosphere to 10⁻¹¹ Torr. The controller's separately packaged power supply provides

cooler operating temperature, resulting in longer component life—as well as conserving valuable panel space by mounting the power supply remotely (if desired). For more details on GPC Vacuum Gauge Controllers, call 1-800-776-6543 and ask for Warren.

GRANVILLE-PHILIPS

For More Information Circle No. 420

DESIGN ENGINEERING PRODUCT SHOWCASE



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For More Information Circle No. 421



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Silicone-based oriented-wire shielding from Instrument Specialties provides environmental protection and EMI attenuation to 100 dB in the E field and 50 dB in the H field. It is available in strips up to 18 ft. and 36 in. sheets which can die cut into complex shapes.

For further information, contact
Arthur J. Johnson

Instrument Specialties Co., Inc.

Delaware Water Gap, PA 18327,
Tel: 717-424-8510 Ext. 149, Fax: 717-424-6213.

For More Information Circle No. 424
See Us at NDES Booth No. 1372

Mini-Remote-Head Color CCD Cameras



Ideal for microscopes, medical imaging, or machine vision, Cohu's new 8280 Series High Performance Color Mini-Remote-Head CCD cameras feature detachable cables in lengths of up to 100 feet. Available in NTSC/Y-C, PAL/Y-C, and RGB models, they incorporate the latest on-chip microlens technology.

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For More Information Circle No. 427

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For More Information Circle No. 430



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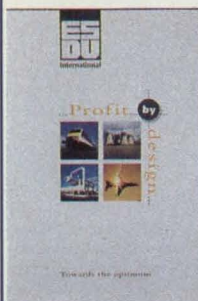
The Convector™ Vacuum Gauge from Granville-Philips is designed to improve productivity in vacuum process applications from atmosphere to 10⁻⁴ Torr. The gauge's fast response helps reduce cycle time delays. Stability and excellent repeatability help reduce product defects

and downtime caused by gauges prone to calibration drift.

For more details on GPC Vacuum Gauge Controllers, call 1-800-776-6543 and ask for Dennis.

GRANVILLE PHILIPS

For More Information Circle No. 422



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For More Information Circle No. 425



TECLAB ESD WORKSTATION CATALOG

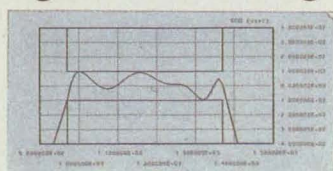
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Teclab,
Kalamazoo Technical Furniture

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For More Information Circle No. 428

Digital Filter Design



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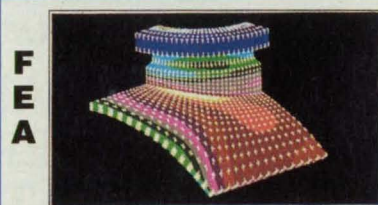
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For More Information Circle No. 429



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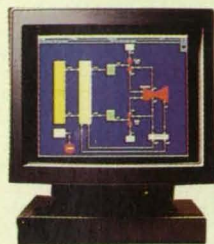
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For More Information Circle No. 309

Powerful New Motion Controller



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Aerotech

For More Information Circle No. 310



HIGH DENSITY SWITCH MATRIX SYSTEMS

The Precision Programmable Patch switch systems provide computer control for a faster, more accurate way to set up complex tests. Features include: solid state and reed relay switches, up to 23,040 crosspoints in one mainframe, frequencies to 1 MHz, and self-test capability.

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For More Information Circle No. 311



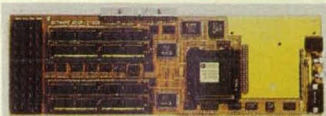
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For More Information Circle No. 312



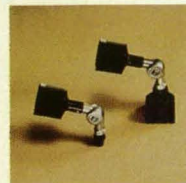
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For More Information Circle No. 318

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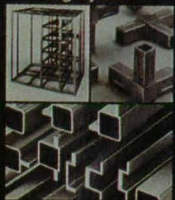
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For More Information Circle No. 449

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AMCO'S NEW MONITORING SYSTEMS

Consoles come in single or multiple bay configurations and are for monitoring type applications. Engineered to accept the company's standard accessories. Models include those with low silhouette bases, sloped front frames & vertical frames, wedge sections & turrets.

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For More Information Circle No. 450

Cooling Devices For Enclosures

AMCO's 26 page 4/C Cooling Device Catalog 850 features a New Motorized Impeller Blower. This new technology in cooling moves a larger volume of air at a lower cost. This extensive line includes centrifugal blowers and tube axial fans. Complete accessories included. **AMCO Engineering Co., 3801 North Rose Street, Schiller Park, IL 60176.** For your free copy call (800) 833-3156 or in Illinois (708) 671-6670.



For More Information Circle No. 487

Instant Amco Enclosures

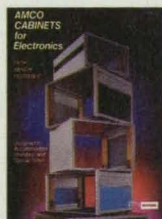
AMCO Catalog 500B features the five work day program that permits selection from three styles of consoles. Frames are black and panels are light blue. The ten work day program guarantees 24" panel width selections of three styles of vertical consoles in any of 19 color choices with black frames. Accessories also available. **AMCO Engineering Co., 3801 North Rose Street, Schiller Park, IL 60176.** Tel. 708/671-6670, FAX: 708/671-9469 or call 1/800/833-3156.



For More Information Circle No. 484

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For More Information Circle No. 485

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Suppressing Spurious Reflections in an Interferometer

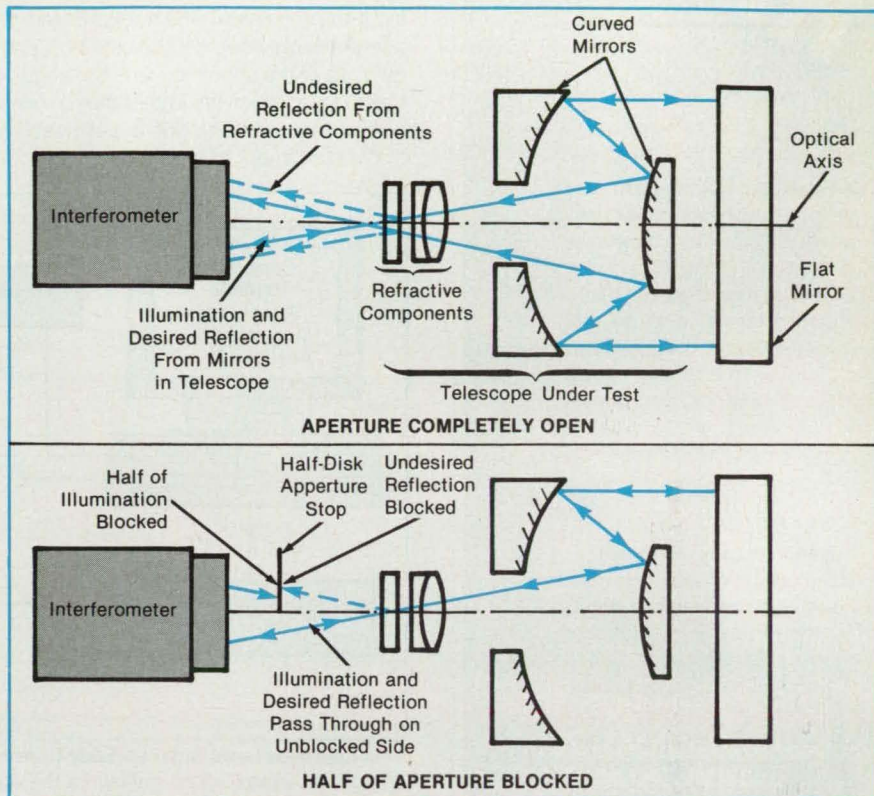
A rotating half-disk aperture stop blocks reflections from surfaces of refractors.

NASA's Jet Propulsion Laboratory, Pasadena, California

The dynamic-aperture fringe discriminator is a simple device that enhances the operation of an interferometer of the spherical-wave-front type that is used to test lenses, telescopes, and other optical instruments. This device suppresses reflections from the surfaces of refractive optical elements in the instrument and/or the test setup. It is desirable to suppress such reflections because they give rise to spurious interference fringes, which can obscure the main fringes that are of interest in characterizing the instrument.

The upper part of the figure shows how the unwanted reflections are formed in the testing of a catadioptric telescope. A straightforward ray-tracing analysis provides the key to suppression of these reflections: Light rays that contribute to the main fringe pattern return back upon themselves, reentering the interferometer on the same side of the optical axis from which they came, whereas rays reflected from the surface of a refractive component re-enter on the opposite side of the optical axis. Therefore, the reflections from the refractive components can be eliminated by blocking off half of the interferometer aperture at a time.

While blocking half of the aperture suppresses the unwanted reflections, it also extinguishes the main interference pattern from that portion of the instrument that would otherwise be illuminated through the now-blocked half. To provide for effectively continuous viewing of the entire main interference pattern, the blocking apertures can be rotated about the optical axis or shifted rapidly from one side to the other. In a prototype, a half-disk aperture stop is



Reflections From Refractive Optical Components can be eliminated by blocking half of the interferometer aperture.

rotated mechanically. Alternatively, a liquid-crystal light valve could be activated in a half-disk opaque/transparent pattern that would be switched back and forth electrically.

This work was done by Lawrence J. Steimle and David L. Thiessen of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 45 on the

TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 22]. Refer to NPO-18478.

Improved Imaging With Laser-Induced Eddy Currents

Changes in the impedance of the eddy-current coil are measured in absolute instead of relative units.

Goddard Space Flight Center, Greenbelt, Maryland

A system that tests a specimen of material nondestructively by laser-induced eddy-current imaging has been improved by changing the method of processing of the eddy-current signal. In this as in prior systems of this type, the surface of a specimen is scanned with a modulated laser beam. The local heating of the specimen at the laser-beam spot creates thermal and stress waves, which cause small but detectable changes in the impedance of

an eddy-current probe coil located beneath the specimen (see figure). Measurements of the impedance at each of many locations in a raster scan of the laser beam across the specimen can be analyzed to detect imperfections, determine properties, or assess the quality of the specimen.

Because the changes in impedance are synchronous with the modulation of the laser beam, a lock-in amplifier can be used to aid in the detection of the modulation

of the impedance values. The impedance measurements are made with a pancake-shaped commercial eddy-current probe coil connected to a commercial impedance gain-and-phase analyzer. The analyzer is connected to the lock-in amplifier through a personal computer, which controls the system (including the raster-scanning mirror).

Measurements of the real and imaginary components of the impedance of the

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For More Information Circle No. 574

coil provide better indications of the local properties of the specimen than do the arbitrary proportional signals used in prior systems of this type. The change in impedance is given by

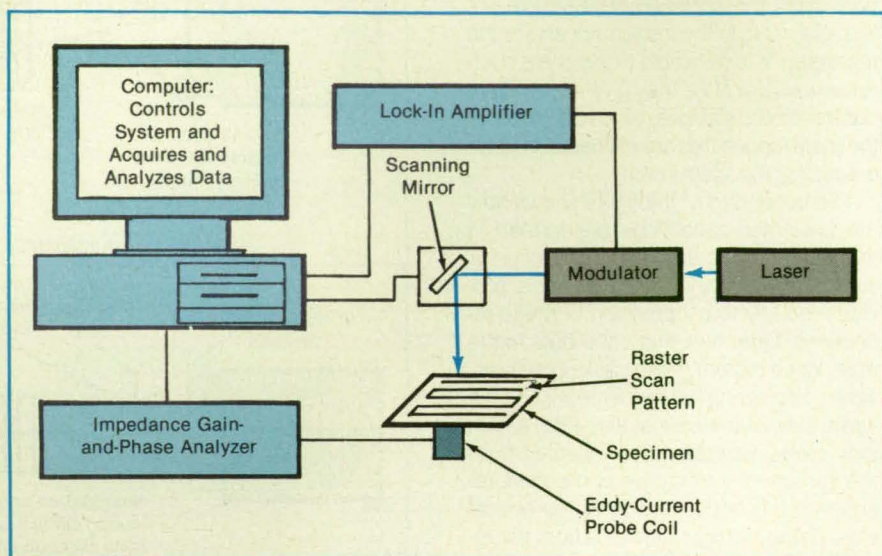
$$\Delta Z = \frac{1}{l^2} \iint_s \left(E^2 \frac{\partial \sigma}{\partial T} + j H^2 \omega \frac{\partial \mu}{\partial T} \right) \Delta T ds$$

where Z = impedance, I = current in the coil, s denotes the surface area of the specimen faced by the probe, ΔT = the local thermoelastic effect (expressed as a temperature rise), σ is the electrical conductivity of the specimen, ω is the angular frequency at which the impedance is measured, and μ is the magnetic permeability of the specimen. In a demonstration, the

impedance components of the coil at room temperature were a resistance of 14.3 Ω and a reactance of 82.5 Ω ; laser-induced changes in resistance were about 3 Ω , while laser-induced changes in reactance were about 4 Ω .

This work was done by Engmin J. Chern of Goddard Space Flight Center. For further information, Circle 47 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 22]. Refer to GSC-13386.



This Improved Laser-Induced Eddy-Current Imaging System includes an impedance gain-and-phase analyzer that measures the impedance of the eddy-current probe coil while a modulated laser beam performs a raster scan of the specimen. Changes in the impedance of the coil are caused by the thermal and stress waves induced in the specimen by the laser beam. The depth of penetration of the thermoelastic waves is controlled by adjusting the modulation frequency of the laser beam.

Electronic Catalog of Extragalactic Objects

This astronomical data base is accessible to researchers and librarians.

NASA's Jet Propulsion Laboratory, Pasadena, California

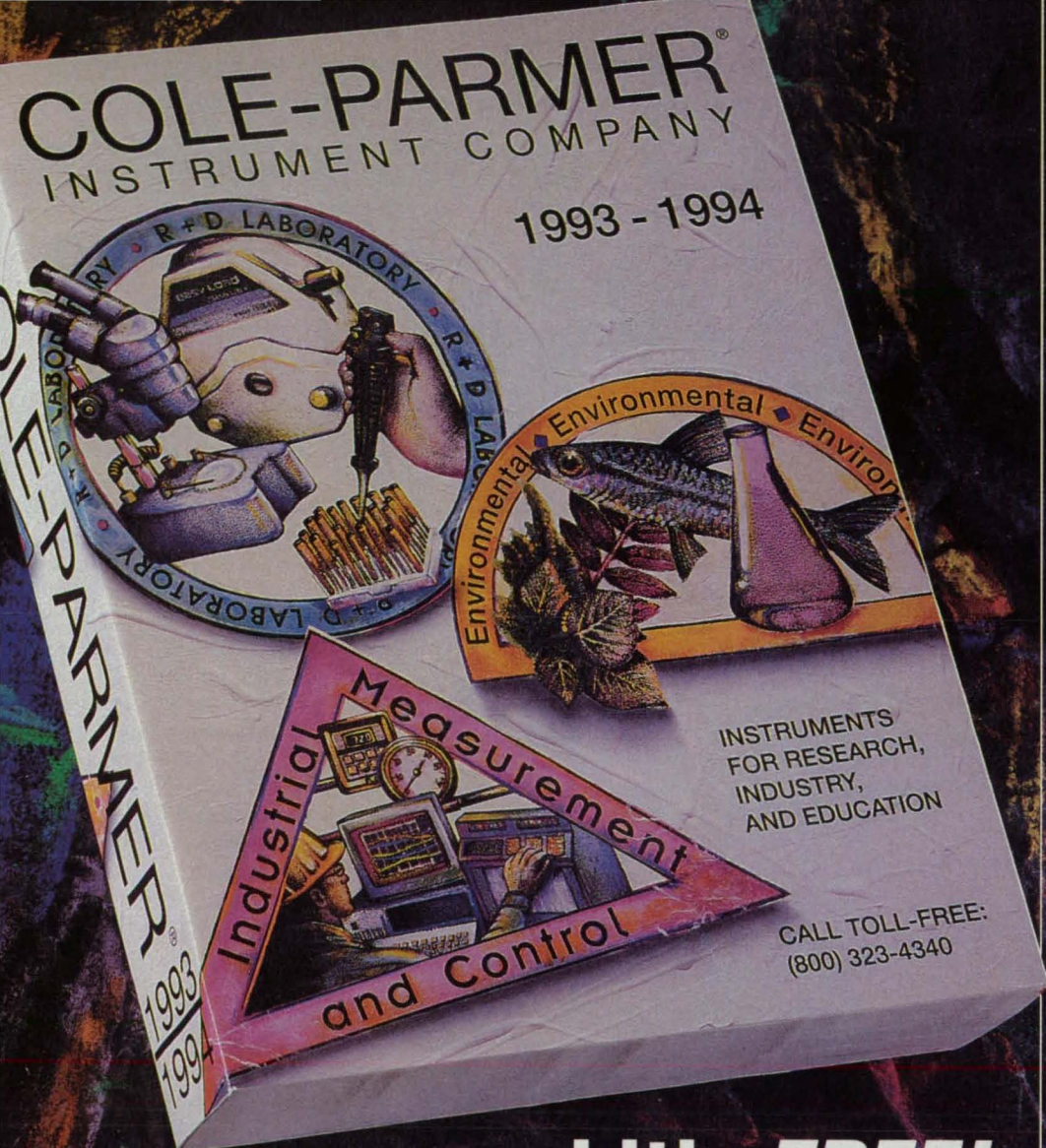
The NASA/IPAC Extragalactic Database (NED) is a publicly accessible computerized catalog of published information about extragalactic observations. Organized by astronomical objects and implemented as a relational data base, the catalog provides both data and references. It is continually updated.

The NED was developed to accommodate increasingly large sets of data from surveys, exponentially growing literature, and the trend among astronomers to take a multispectral approach to astrophysical problems. It can be used by researchers and librarians who have access via electronic network connections to the NED

computer, which is located at the Infrared Processing and Analysis Center (IPAC) at Caltech, Pasadena, California.

At present, NED offers 400,000 names with cross-identifications for 200,000 extragalactic objects. It carries accurate positions, indicative basic data, notes, 250,000 bibliographic references, and 5,000 abstracts from major journals published since 1988.

This work was done by George Helou and Barry F. Madore of the Infrared Processing and Analysis Center at Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 106 on the TSP Request Card. NPO-18407



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Converting Gravity-Bin Parameters to Spherical Harmonics

The traditional representation of the gravitational field can be recovered by a new method.

*NASA's Jet Propulsion Laboratory,
Pasadena, California*

A new method of computation of the gravitational field of the Earth provides for the conversion of gravity-bin parameters to the coefficients of spherical harmonics. The gravity-bin parameters are perturbations of a satellite orbit that represent corrections for the gravitational field—in effect, gravitational "bumps." Traditionally, these corrections have been represented by spherical harmonics, which are mathematically rigorous but do not necessarily lend themselves to efficient computation.

Developed for use in analyzing the trajectory of a spacecraft in a nearly repeating low orbit around the Earth, the gravity-bin parameters represent small measured corrections, at specified times, to positions predicted for those times by use of a nominal mathematical model of the gravitational field. The gravity-bin parameters provide for computational efficiency, both in predicting the trajectory and in recovering data on the gravitational bumps from the measured trajectory. The gravity-bin approach was described in more detail in "Computing Gravitational Bumps From Repeating-Orbit Data" (NPO-17925), *NASA Tech Briefs*, Vol. 15, No. 5 (May 1991), page 52, and "More About Gravitational Bumps and Repeating Orbits" (NPO-18189), *NASA Tech Briefs*, Vol. 15, No. 5 (1991), page 52.

In the original gravity-bin approach as described in the cited prior articles, one can estimate the coefficients of the spherical harmonics via a computation that involves finite differencing of the gravity-bin parameters. However, the result differs from the estimate obtained in the traditional approach, in which spherical harmonics are carried through all stages of the analysis. The difference between the results is caused by a subtle effect: In the conversion from gravity-bin parameters to coefficients of spherical harmonics, noises in acceleration data are treated as though they were uncorrelated even though they are correlated. As a result, the data-weighting matrices in the traditional and the original gravity-bin approach differ from each other, leading to different results.

The new method makes it possible to retain the computational efficiency of the gravity-bin approach and to obtain the same estimate of the coefficients of spherical harmonics as in the traditional approach. The first and largest part of the computation in the new method is the computation of the gravity-bin parameters as in the original gravity-bin approach. Next, the gravity-bin parameters are treated as pseudomeasurements and processed by use of a standard square-root-information-filter technique. Provided that the method is implemented by a suitable algorithm that (1) divides long (about 10 days) trajectories into shorter segments (about 2 hours), (2) accurately computes the appropriate ties between segments and (3) accounts properly for the correlations among pseudomeasurements, the result is the same as that obtained by estimating the coefficients of the spherical harmonics directly from the measurements.

This work was done by Jiun-tsong Wu, William I. Bertiger, and Sien-Chong Wu of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 4 on the TSP Request Card. NPO-18327

Photothermal Monitoring of Curing of Polymers

Time-resolved infrared radiometry would be adapted to production.

Marshall Space Flight Center, Alabama

Time-resolved infrared radiometry (TRIR) would be adapted to monitoring the curing of some polymers in production, according to a proposal. The proposal was made as part of a continuing effort to perfect the production of hydroxy-terminated polybutadiene (HTPB) for use in the liners of solid-fuel rocket motors, but the underlying concept may also be applicable to monitoring the changing states of many other materials in process.

TRIR is a photothermal technique in which one heats a small spot on a specimen with laser light for a short time while monitoring the evolution of the surface temperature by use of a noncontact radiometer. It has been shown that a change in the rate of increase of temperature is indicative of simultaneous change(s) in the thermal properties (conductivity, heat capacity), density, and/or optical properties (absorbance, reflectance) of the surface layer of the specimen. Furthermore, a change in the linearity of the temperature rise vs. the square root of time can be shown to be indicative of the change in the thickness of the surface layer. Because the curing process affects the thermal properties, density, optical properties, and/

or thickness, it should, therefore, be possible to use TRIR to monitor the process.

Heretofore, TRIR and related methods like pulsed photothermal radiometry have been used in limited laboratory evaluations to monitor curing of epoxies. In an initial test of TRIR monitoring of the curing of HTPB, it was demonstrated that TRIR readings are affected strongly by the gelation stage of the curing process. It was also shown that TRIR shows promise for characterizing the later stages of cure, including the ability to detect the "over-cured" condition. If the hypothesis concerning the utility of TRIR proves true, then TRIR will provide information on the state of cure similar to the information now provided by Fourier-transform infrared spectroscopy (FTIR). However, TRIR offers an advantage over FTIR in that TRIR is a non-contact technique that can be implemented with remotely situated equipment and is, therefore, better suited to use in production.

This work was done by Michael Rooney of Science Applications International Co. for Marshall Space Flight Center. No further documentation is available.
MFS-28619

Improved Statistical Model of 10.7-cm Solar Radiation

Short-term fluctuations can be simulated more accurately.

Lyndon B. Johnson Space Center, Houston, Texas

An improved mathematical model simulates the short-term (daily) fluctuations of the flux of 10.7-cm-wavelength solar radiation

during a 91-day averaging period. This flux, called the "F10.7 flux" by specialists in the field, is important as a measure of solar activity and because it is highly correlated with the ultraviolet radiation that causes fluctuations in the heating and density of the upper atmosphere. Furthermore, the F10.7 flux is easily measurable at the surface of the Earth, whereas the ultraviolet flux is not.

The development of the model began with statistical analyses of daily measurements of F10.7 flux that were accumulated during the three 11.1-year solar cycles from the year 1956 through September 1989. In one analysis, the measurement data were partitioned into 400 91-day averaging periods, each of which overlapped the preceding period by 61 days. The first three probability-weighted moments (PWM's) of the data for each 91-day period were computed. Then a three-dimensional plot of the

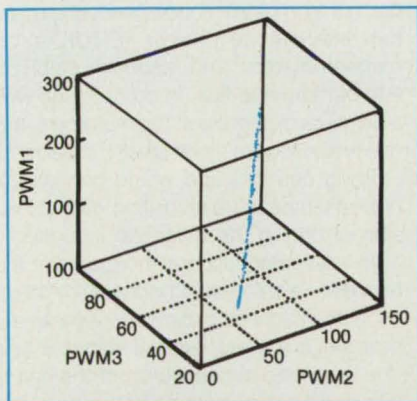
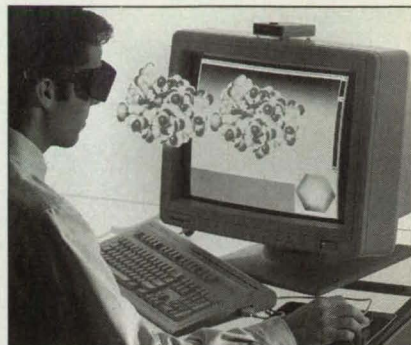


Figure 1. This Scatter Plot shows the linear relationship among the first three probability-weighted moments (PWM's) of the 400 overlapping sequences of daily F10.7 values.

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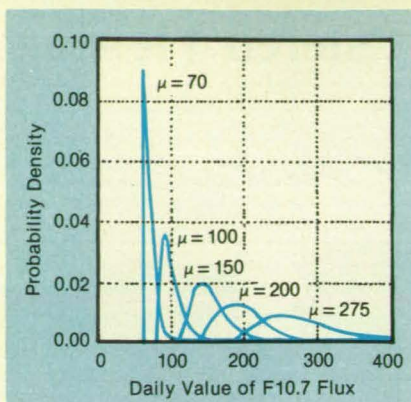


Figure 2. Weibull Probability-Density Functions are shown for representative mean values (μ) of the 91-day mean solar flux.

400 triplets of PWM values was made, with each axis of the plot representing one of the three PWM's. Remarkably, the scatter plot showed a simple linear relationship among the PWM's (see Figure 1).

This linear relationship has two important consequences for the development of the improved model. The first consequence is that PWM2 and PWM3 can both be expressed as simple linear functions of PWM1, which is identical to the mean. The second consequence is that a three-parameter generalized extreme-value distribution determined by the three PWM's can, therefore, also be obtained from the mean. In this case, the data dictate the choice of a Weibull distribution (see Figure

2), which is one of the three forms of the generalized extreme-value distribution.

An autocorrelation function of the daily F10.7 values was also computed for each of the 400 91-day intervals by fitting an exponential distribution to each to determine a time constant, τ . After analysis of these fits, one value of τ that describes the correlation reasonably well during any part of the solar cycle was selected.

Thus, the improved model represents the F10.7 data as an exponentially correlated, Weibull-distributed random variable. In a test of the validity of the model, Weibull parameters were evaluated for various 91-day means, then used in a Weibull random-number algorithm in conjunction with an exponential-correlation algorithm to synthesize daily F10.7 values. The synthetic values were found to be in close statistical agreement with actual values from the 91-day periods.

This work was done by John D. Vedder and Jill L. Tabor of McDonnell Douglas Corp. for Johnson Space Center. For further information, Circle 27 on the TSP Request Card. MSC-21815

Paramagnetic-Salt Thermometer With Flux Pump and SQUID's

Resolution would be enhanced by reduction of drift, and magnetizing currents could be smaller.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates schematically a proposed paramagnetic-salt low-temperature thermometer that would incorporate an improved superconducting magnetic-flux pump, multiple superconducting quantum interference devices (SQUID's) as magnetometers, and feedback stabilization of magnetic flux. In comparison with older paramagnetic-salt thermometers, this one would require much smaller initial magnetizing currents and would provide improved temperature resolution via suppression of drift in the magnetic induction.

In a paramagnetic-salt thermometer, the temperature is measured indirectly by measuring the magnetic induction in a paramagnetic salt in a known applied magnetic field (the magnetic susceptibility of the salt is a known function of temperature). Heretofore, the applied magnetic field has been generated initially by use of a large current in an electromagnet, and the field was maintained thereafter by trapping it in a



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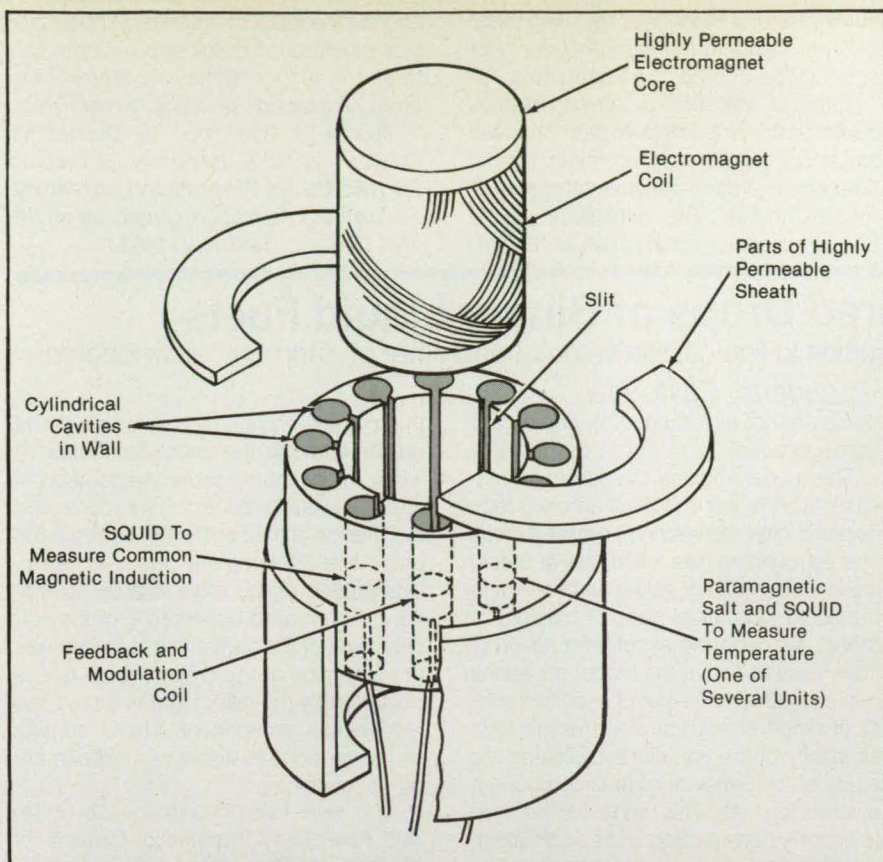
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For More Information Circle No. 466



Cylindrical Cavities in the wall of the superconducting cylinder would share a common induction with the central void, being connected to the void by slits. Sensors would be placed in the wall cavities.

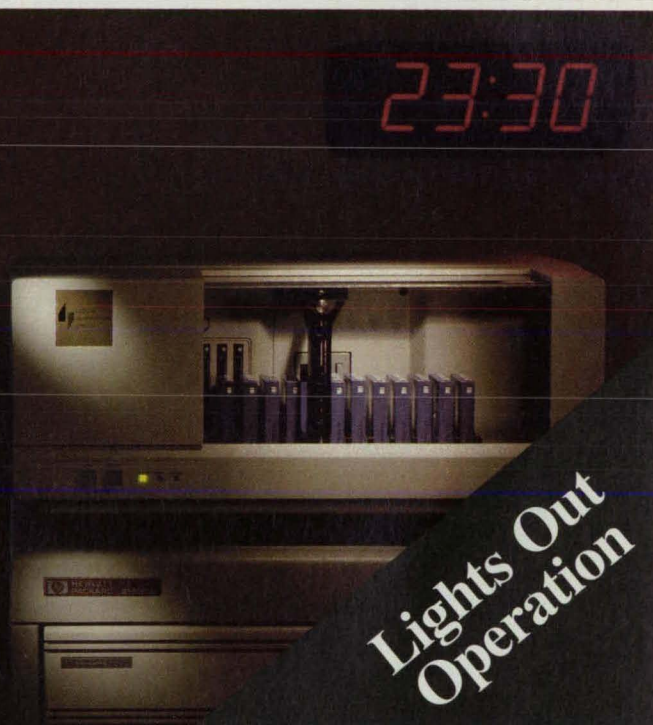
superconducting cylinder in which the salt and magnetometer were placed. The resolution of the temperature determined by this technique has been limited by a slow relaxation of the magnetic induction; the relaxation begins at the moment of initial trapping and continues for days.

In the proposed apparatus, the wall of the superconducting cylinder would include parallel cylindrical holes connected through slits to the central void. The cylinder would be surrounded by a highly magnetically permeable sheath, which would provide a low-magnetic-reluctance path to facilitate the initial magnetization. An electromagnet wound on a highly permeable core would be inserted in the central void and energized while the cylinder was above the superconducting-transition temperature. Because of the low reluctance of the core and sheath, a modest current (≤ 1 A) would result in a relatively large magnetic induction (typically, 0.1 to 2 T). The apparatus would then be cooled below the superconducting-transition temperature, the current in the electromagnet would be turned off and the electromagnet removed from the void, and the magnetic flux would remain trapped in the void because of the superconductivity.

Because the trapped magnetic induction would be common to all of the small cylindrical wall cavities and the central void, a SQUID magnetometer or a super-



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conducting flux-transformer input coil in one of the wall cavities could be used to monitor that induction. Another coil placed in another wall cavity would be energized to change the induction. The current applied to the second coil could be controlled to compensate for changes in the measured magnetic induction (thereby providing feedback stabilization of the magnetic in-

duction) and/or modulated by a sinusoidal or other signal to increase the signal-to-noise ratios of other measurements.

Each of the remaining wall cavities could contain a sample of paramagnetic salt and a SQUID magnetometer, so that one could obtain multiple temperature measurements. The sensitivity of the SQUID magnetometers (down to 10^{-16} T)

and the feedback arrangement should provide stabilization of the applied induction to part in 10^{15} or 10^{14} during times of the order of seconds or days, respectively.

This work was done by Donald M. Strayer and Ulf E. Israelsson of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 48 on the TSP Request Card. NPO-18534

Evaporation of Clustered Drops of Binary-Liquid Fuels

Interactions among evaporation, diffusion in liquids, slip velocity, and other phenomena are modeled.

NASA's Jet Propulsion Laboratory, Pasadena, California

A report repeats and elaborates upon the information presented in "Diffusion of Mass in Evaporating Multicomponent Drops" (NPO-18206), *NASA Tech Briefs*, Vol. 16, No. 7 (July 1992), page 60. It is one in a series of reports, by the same authors, that discuss various aspects of the evaporation and combustion of sprayed liquid fuels.

The report presents the details of a mathematical model of evaporation of a binary liquid from both dense and dilute clusters of drops. The liquid is assumed to consist of two chemical components, one of which is much less volatile. The model takes account of circulatory motion within the drops induced by shear from the flow of the surrounding gas past the drops, and of turbulence in the atmosphere just outside clusters of drops. It also takes into account the diffusion of the component liquids within the drops (that is, the

drops are not assumed to be chemically homogeneous).

The model enables the parametric investigation of the effects of ambient temperature, initial slip velocities between drops and surrounding gas, initial radii of drops, initial proportions of solute and solvent in the liquid, and initial sizes of clusters of drops. Although the simplifying assumptions used to derive the model equations might result in some loss of accuracy and/or of range of applicability, the resulting simplicity of the equations facilitates the study of the behavior of multicomponent evaporating fuels. This model can be used to simplify considerably more sophisticated models of spray evaporation in dense regions of combustors. Since this model is simpler, the computational costs will be reduced accordingly.

Results of computations performed with

the model are presented. Analysis of the results leads to the conclusions that (1) when the cluster is dilute, evaporation of the more-volatile component is controlled by diffusion of the component liquids in the drops and (2) when the cluster is dense, evaporation of the more-volatile component is controlled by stripping of the surface layer of the drops; that is, by the rate of regression of the drops, which rate is controlled by the rate of evaporation of the less-volatile component. These conclusions are found to agree with experimental observations.

This work was done by Josette Bellan and Kenneth G. Harstad of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "A Model of the Evaporation of Binary-Fuel Clusters of Drops," Circle 2 on the TSP Request Card. NPO-18452

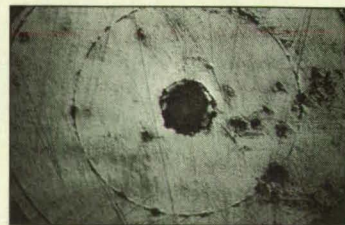
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Far-Infrared Spectrometer Measures Stratospheric Hydroxyl

Measurements should contribute to understanding of the "ozone hole" in the stratosphere.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Far Infrared Limb Observing Spectrometer (FILOS) is a balloon-borne instrument that measures far-infrared emission from the limb of the atmosphere. It operates in two spectral channels in the wave-number range of 101 to 118 cm^{-1} , which range contains spectral lines of several molecules and radicals of current scientific interest. The instrument is designed primarily to obtain data on the distribution of hydroxyl radicals, which play a central role in the chemistry of ozone in the stratosphere.

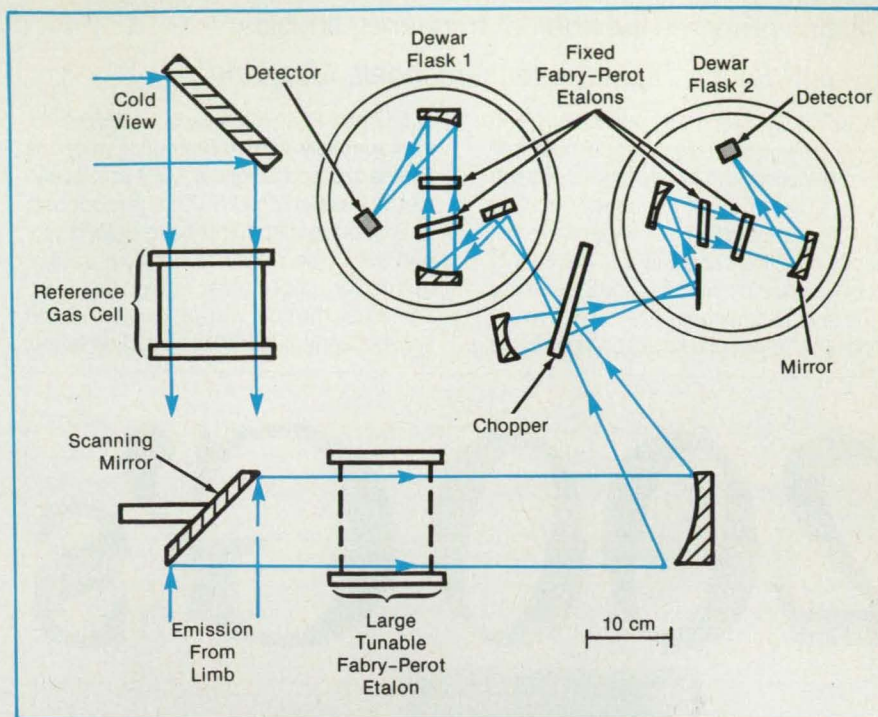
Depending on the orientation of a scanning mirror, the instrument views either the limb of the atmosphere or a reference cell containing a known gas at a known concentration (see figure). After reflection from the scanning mirror, the entering radiation passes through a large Fabry-Perot etalon, which consists of two gold-coated nickel meshes with a diameter of 10 cm and a separation of 10 cm . The separation is adjusted slightly by means of voice coils (and monitored with linear variable-displacement transducers) to tune the etalon over the wave number range of interest.

The radiation is then reflected to a chopper, which directs it alternately into one, then the other of two Dewar flasks, each of which is dedicated to one of the two spectral channels. Each Dewar flask contains two smaller Fabry-Perot etalons cooled to 4 K by liquid helium, made of gold-coated copper mesh, with diameters of 2.5 cm and separations of 2 mm and 0.1 mm , respectively. The function of these two etalons is to filter out a single spectral order of the large etalon, thereby defining the spectral channel.

Additional spectral filtering is provided by cooled crystals of potassium chloride, calcium fluoride, and quartz, and by a sheet of black polyethylene placed in front of the window of each Dewar flask to block near-infrared and visible light. The final filtered radiation is detected by gallium-doped germanium photoconductors mounted in integrating cavities; the outputs of the photoconductors are amplified by cooled transconductance amplifiers. The overall spectral resolution of the instrument is that of the large Fabry-Perot etalon, which is 0.0017 cm^{-1} .

The instrument has been used thus far to measure emissions from OH , H_2O , O_3 , (and reference-cell emissions from HDO) at wave numbers near 101 cm^{-1} . It can also be equipped to measure HO_2 and OH at 118 cm^{-1} or HCl at 104 cm^{-1} .

This work was done by Dean B. Peterson and Herbert M. Pickett of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 58 on the TSP Request Card. NPO-18541



The Far Infrared Limb Observing Spectrometer contains one tunable Fabry-Perot etalon, plus two fixed etalons in each of two channels. The instrument measures radiation at wavelengths $\approx 99\text{ }\mu\text{m}$, characteristic of hydroxyl and other radicals and molecules relevant to the chemistry of ozone in the atmosphere.

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Self-Frequency-Doubling Glass-Fiber Laser

Exposure to intense fundamental and second-harmonic radiation prepares the fiber for frequency doubling.

Goddard Space Flight Center, Greenbelt, Maryland

A specially prepared germanium and phosphorous-doped glass optical fiber that is further doped with neodymium has been shown to act as a self-frequency-doubling laser. The preparation that imparts the frequency-doubling capability into the fiber is accomplished by simultaneous exposure of the fiber to coherent radiation at a wavelength of 1.06 μm and its second harmonic

at 532 nm, at an intensity of 5 GW/cm² for approximately 15 min. Thereafter, when the fiber is exposed to light at 1.064 μm , its harmonic wavelength at 532 nm is produced.

Previous experiments have yielded second harmonic conversion efficiencies in germanium-doped glass as high as 13 percent when the fiber was prepared and then subsequently illuminated by a Q-switched,

mode-locked Nd:YAG laser lasing at 1.06 μm . A 5-percent conversion efficiency was achieved using a continuous-wave, mode-locked laser. By preparing a glass fiber that has been doped with neodymium and then building an oscillator around the fiber, one can have the fiber pumped at the neodymium absorption wavelength (810 nm) and caused to lase, producing both the neodymium fundamental wavelength of 1.064 μm and the second harmonic at 532 nm. Mode-locking this laser (see figure) will produce larger fundamental intracavity intensities and therefore greater second-harmonic generation. The contemplated use of high-power laser diodes to generate the pump light should enable the development of compact sources of high-intensity infrared and visible light for terrestrial and space applications.

The concept of the self-frequency-doubling fiber laser, with further refinements, could eliminate the need for the expensive, easily damaged, nonlinear crystals currently used. It would thus enable one to avoid the loss and damage mechanisms associated with the interfaces of nonlinear crystals as well as to eliminate angle/temperature phase-matching tuning.

The basic physics of second-harmonic generation in glass fibers is not completely understood. It has been conjectured that the intense radiation used to prepare the fiber gives rise to a periodic dc electric field inside the fiber and that this field breaks the symmetry of the glass, leading to a second-order dielectric susceptibility and thereby producing a self-organized phase-matching grating. This self-organized susceptibility grating may be capable of conversion efficiencies greater than those of currently used frequency-doubling crystals.

At this initial stage of development, the self-frequency-doubling glass-fiber laser has been limited by the quality of the second-order susceptibility grating that is "written" during the preparation, the available pump power, and the rate of absorption of the second harmonic. Continued basic research on the formation and optimization of the gratings is necessary.

The technology of fiber lasers is maturing, with additional rare-earth elements promising operation at many different wavelengths. Although most of the work in fiber preparation has been performed at 1.06 μm , work is underway to determine the limits of frequency response with respect to doubling in glass. Thus far, frequency doubling has also been demonstrated in

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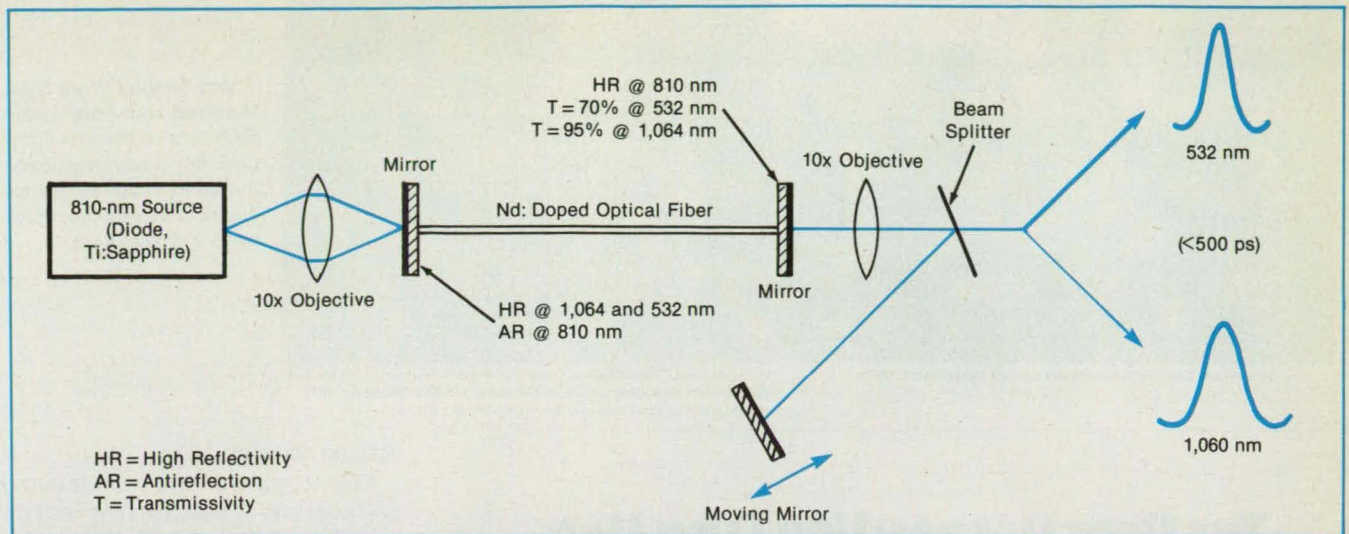


For More Information Circle No. 690

glass-fibers operating at wavelengths of 0.647 and 1.319 μm .

This work was done by Mark D. Selker and Joseph L. Dallas of **Goddard Space**

Flight Center. No further documentation is available. GSC-13466



An **Experimental Setup** is shown for the mode-locked, self-frequency doubling fiber laser.

Classification of Terrain in Polarimetric SAR Images

Two algorithms — one for supervised, the other for unsupervised classification — have been tested.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two algorithms that process polarimetric synthetic-aperture-radar (SAR) data have been found effective in assigning the various parts of SAR images to classes that represent different types of terrain. These algorithms partially automate the interpretation of SAR imagery, reducing the amount of photointerpretation needed and putting the whole interpretation process on a more quantitative and systematic basis.

The first algorithm is more advantageous when accurate data from ground surveys are available to "train" the algorithm to distinguish between different types of terrain according to their different radar-polarimetric properties. This algorithm implements a Bayesian classification scheme that is said to be "supervised" by use of the training data.

The Bayesian classification of SAR imagery was described in a previous issue of *NASA Tech Briefs*. To recapitulate: the polarimetric data for each picture element are formulated into a feature vector and assigned to the class in which the vector most probably belongs by virtue of (1) the distance in feature-vector space between it and other, averagelike feature vectors that are considered to be representative of the various classes of terrain and (2) the a priori probability of each of these classes. The supervised-classification algorithm can be used on the full (absolute magnitude and phase) polarimetric data or on such subsets as relative magnitude and phase data, absolute or relative magnitude (without phase) data, or phase (only) data.

The second algorithm is simpler. It implements a classification procedure that

is said to be unsupervised. This algorithm is more advantageous when training data are unavailable or poorly known. This algorithm classifies the terrain in each picture element according to the relationship be-

tween the polarimetric properties of the received signal in various states of transmitting polarization and the corresponding polarimetric properties of such model scatterers as corner reflectors and rough di-

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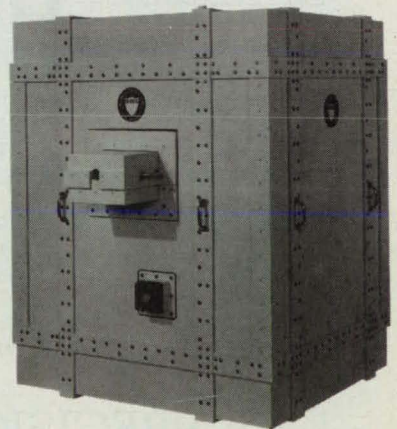
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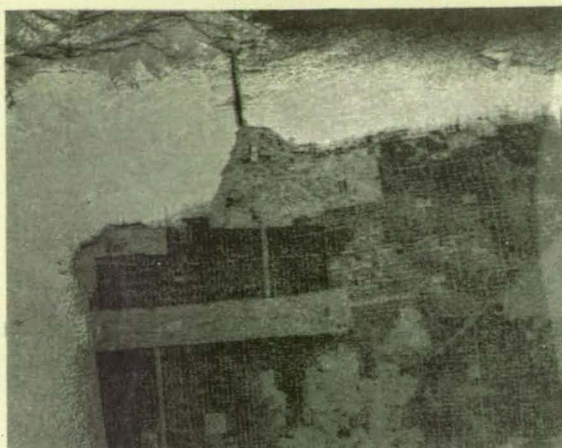


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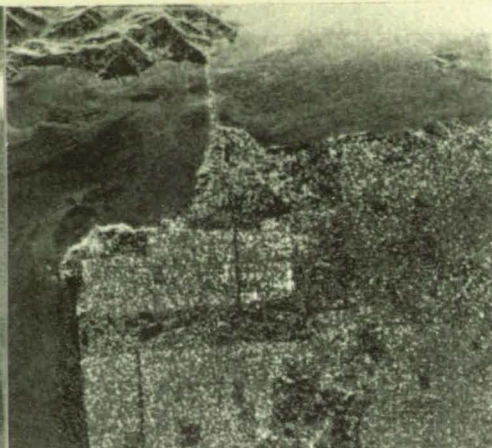
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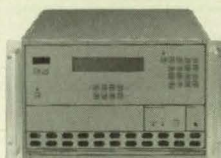
Unsupervised Classification Based on Simple Mathematical Models That Incorporate Gray Levels of the Return Power Measured With Horizontal Transmitting and Receiving Polarizations

These Images Were Synthesized from polarimetric SAR data on the San Francisco Bay area by algorithms that assign each picture element to a class that represents a type of terrain.

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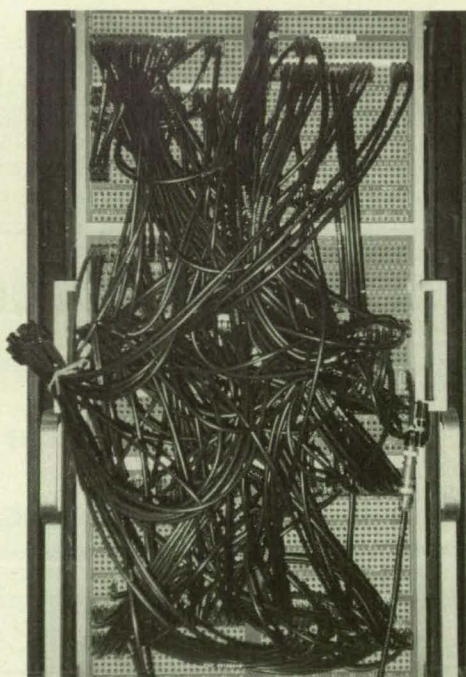
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electric surfaces.

Both algorithms have been tested on SAR polarimetric data from the San Francisco Bay area (see figure). As one would expect intuitively, supervised classification with the full polarimetric data resulted in the lowest probability of error.

This work was done by Jakob J. van Zyl of Caltech and Jin A. Kong, Robert T. Shin, Harold Lim, Albert Swartz, and Simon H. Yueh of the Massachusetts Institute of Technology for NASA's Jet Propulsion Laboratory. For further information, Circle 69 on the TSP Request Card. NPO-18067

Simulation of Fluctuating Geomagnetic Index

Simulated a_p data have statistical properties that resemble those of real data.

Lyndon B. Johnson Space Center, Houston, Texas

A mathematical model produces synthetic geomagnetic-index (a_p) data that include short-term fluctuations like those of the real a_p data. The geomagnetic index is a measure of geomagnetic activity: it is computed from measurements of fluctuations in the geomagnetic field taken at 12 high-latitude stations every 3 hours. It is used in studies of interactions between the solar wind and the Earth, especially in studies of the effect of the geomagnetic field upon the heating of the thermosphere by impacts of energetic charged solar-wind particles.

Older mathematical models synthesize moving averages of a_p , reproducing the statistical properties of fluctuations over intervals much longer than 3 hours (e.g., a complete solar cycle of 11 years). A log-normal distribution is incorporated into the model to characterize the 3-hour a_p values

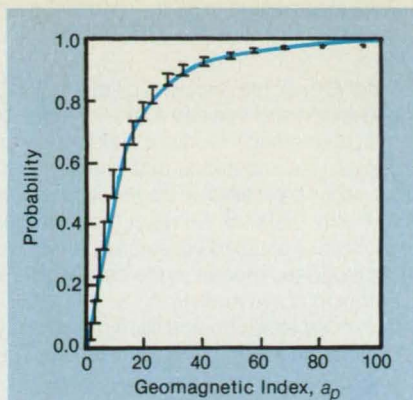


Figure 1. Empirical Values of a_p are indicated by the error bars. The solid line indicates a lognormal distribution.

across an entire solar cycle (see Figure 1). This distribution is combined with a quasi-exponential correlation. The resulting statistical model represents the short-term a_p as a quasi-exponentially-correlated, log-normal-distributed random variable.

As can be seen in Figure 2, synthetic a_p data imitate real a_p data quite well. Analysis shows that the fluctuations in the synthetic a_p values manifest excellent agreement with the historical data base of a_p values. In addition, the first two moments of the model statistical distribution match the corresponding moments of the real data.

This work was done by John Vedder and Jill Tabor of McDonnell Douglas Corp. for Johnson Space Center. For further information, Circle 26 on the TSP Request Card. MSC-21911

Making Optical-Fiber Chemical Detectors More Sensitive

Efficiency increases with the difference in refractive indices.

Langley Research Center,
Hampton, Virginia

Calculations based on the exact theory of the optical fiber have shown how to increase the optical efficiency and, thereby, the sensitivity of an active-cladding step-index-profile optical-fiber fluorosensor that uses evanescent wave coupling. Heretofore, calculations of the propagation of light in such a device have been based on the weakly-guiding and ray-optics approximations, neither of which represents the electromagnetic behavior realistically enough to be useful to improve the design. The weakly-guiding approximation cannot accommodate a large difference between the indices of refraction of the core and cladding. The ray-optics approximation is inapplicable to a few-mode fiber (a ray nec-

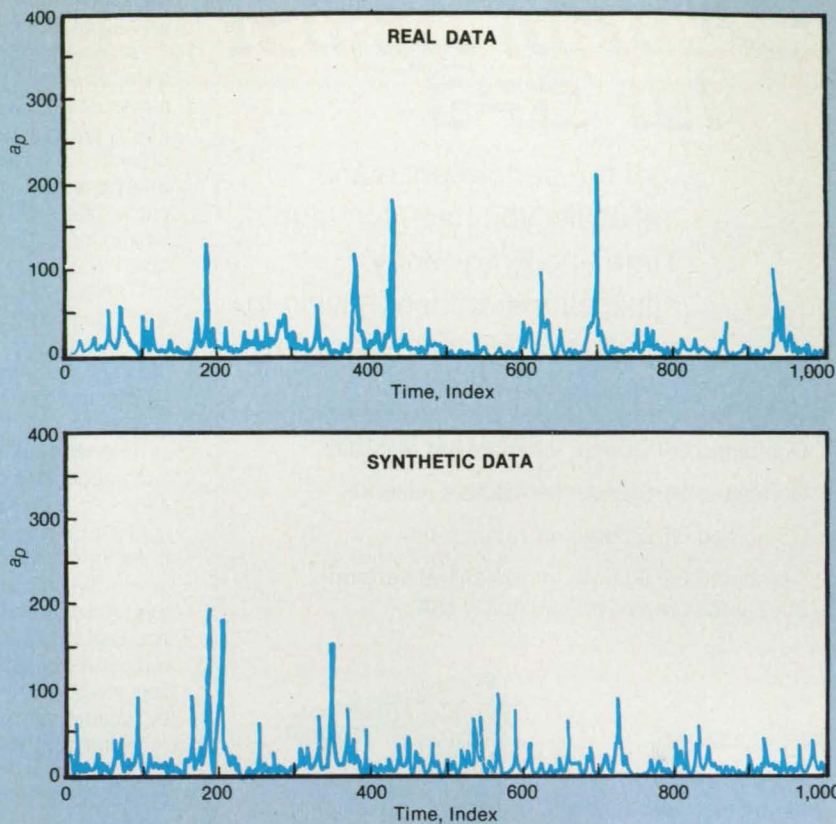
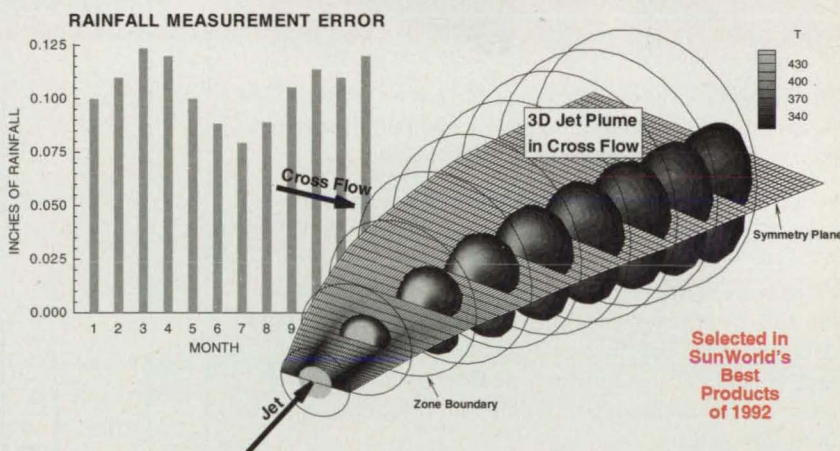


Figure 2. Real and Simulated a_p data exhibit similar fluctuations. Analysis of the two sets of data show that they are statistically similar.

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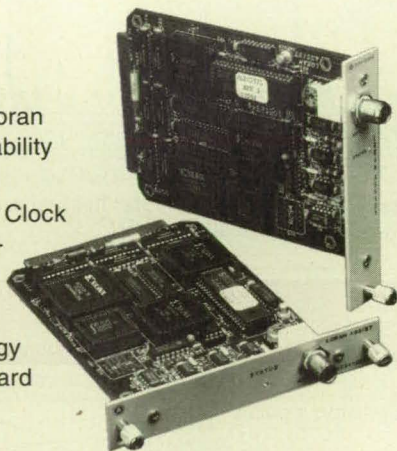
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For More Information Circle No. 641

essarily consists of many wave modes) and to evanescent coupling because coupling of light between the cladding and the core is a wave (not a ray) phenomenon.

An optical-fiber fluorosensor (see figure) includes a core that has an index of refraction n_{core} and a cladding that has a smaller index of refraction n_{clad} . A certain length of cladding includes a matrix material that is permeable to the analyte (the substance that one seeks to detect). A substance that fluoresces selectively in the presence of the analyte is suspended in the matrix material. Some of the light thus emitted from the cladding sources is coupled via evanescent-wave interaction into bound electromagnetic modes in the core which is taken to indicate the concentration of the analyte.

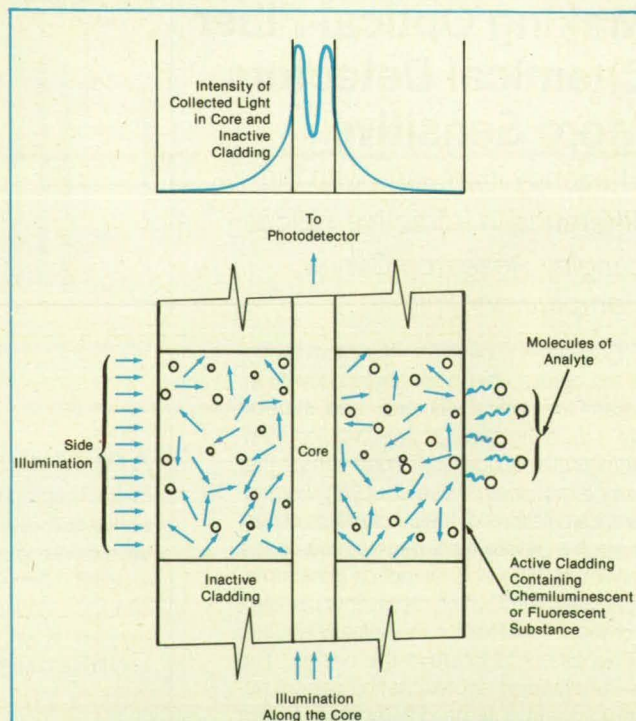
The fluorescence can be excited either by side illumination or by light injection along the core, which is accompanied by evanescent-wave excitation and coupling back into the core. The active substance in the sensitive length of the cladding could be chemiluminescent instead of fluorescent, in which case illumination from an outside source would be unnecessary.

In analyzing the performance of the sensor, one considers the fluorescent and chemiluminescent molecules to act as infinitesimal electric-current sources with random phase and orientation that emit light at a certain frequency. The sensitivity of the sensor is measured in the form of the capture efficiency, which is the ratio between (1) the power that is injected into the core and propagates along it and (2) the total power emitted by the fluorescence or chemiluminescent sources. In order to calculate the efficiency, it is necessary to find the roots of a transcendental equation which are related to the propagation constant of each mode. The equation can be solved numerically by a computer program.

Numerical solutions have been obtained thus far for some specific cases in which the cladding is infinitely thick and the fluorescent or chemiluminescent sources are distributed either uniformly throughout the cladding or else in a thin layer in the core/cladding boundary. The numerical results show that, among other things, the capture efficiency increases with $n_{\text{core}} - n_{\text{clad}}$.

This work was done by Robert S. Rogowski of Langley Research Center and Claudio O. Egalon of the College of William and Mary. For further information, Circle 43 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14525.



This **Optical-Fiber Fluorosensor** contains molecules that fluoresce when illuminated by suitable light in the presence of the analyte. The fluorescence is coupled into and launched along the core by the evanescent-wave interaction.



Microporous Carbon Disks for Sorption Refrigerators

Slow, careful pyrolysis reduces variability of characteristics.

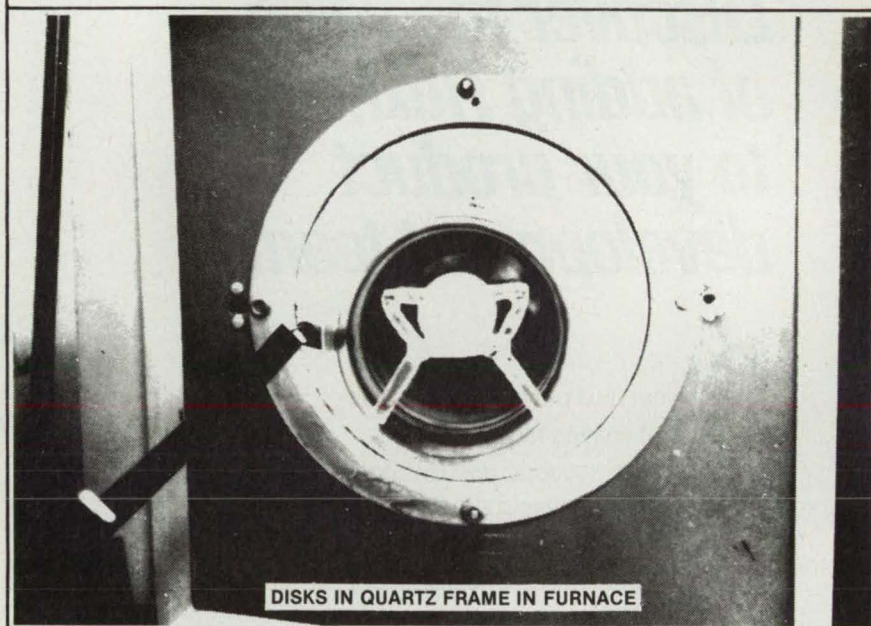
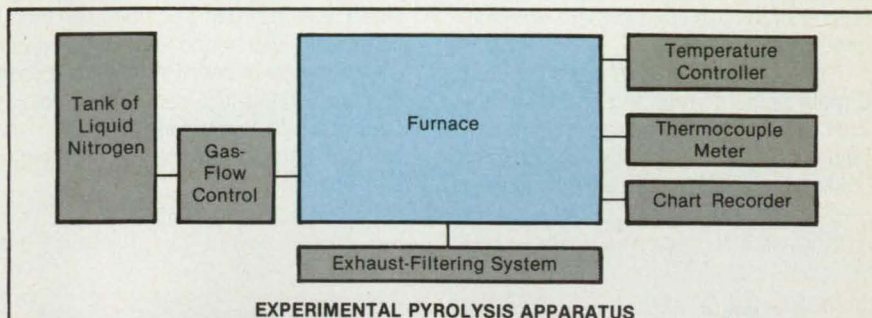
NASA's Jet Propulsion Laboratory, Pasadena, California

Slow, carefully controlled pyrolysis has been found to turn polyvinylidene chloride disks into carbon disks that have small pores and large surface areas. Such disks exhibit the high adsorptivities that make them useful in krypton-sorption refrigerators. In comparison with carbons made from other polymers, carbons made from polyvinylidene chloride have greater adsorptive capacities. However, until now, pyrolyses of vinylidene chloride polymers have yielded variable carbon products with unpredictable microstructures, often with undesirably large pores.

The variability of microstructure has been attributed to a thermal instability that includes synergistic effects of melting and exothermicity at intermediate temperatures during pyrolysis. In the new process, the thermal instability is controlled and, consequently, variability of the product is reduced by careful control of rates of heating, heating times, and the rate of final cooling. One notable feature of the temperature schedule is slow increases of temperature in the critical ranges of 140 to 185 °C and 250 to 500 °C to prevent "runaway" exothermic reactions that would otherwise give rise to blisters, foams with relatively large pores, and cracks, instead of the desired microporosity.

In a demonstration of the new process, small balls of Saran polyvinylidene chloride 1 to 2 mm in diameter were dry-milled into 100-mesh powder. The powder was compressed at 22,200 psi (153 MPa) into disks 2 in. (5.1 cm) in diameter and $\frac{5}{8}$ in. (1.6 cm) thick. The disks were supported on edge in a boat-shaped quartz frame within concentric quartz tubes in a furnace. An atmosphere of flowing nitrogen was maintained in the furnace during the process (see figure). The temperature in the furnace was varied according to the schedule shown in the table. The hydrogen chloride gas given off by the polymer during pyrolysis was carried away by the flowing nitrogen and neutralized in a series of bubblers before entering a laboratory acid-exhaust system.

In comparison with the polyvinylidene chloride disks from which they were made, the resulting carbon disks weighed about 70 percent less and were about 30 percent smaller in both diameter and thickness. The density of the carbon disks was about 0.88 g/cm³. The chemical composition included about 92 percent carbon and 6 percent oxygen; the remaining 2 per-



Disks of Polyvinylidene Chloride were held in a quartz frame in a furnace. The disks were heated in a controlled flow of nitrogen according to the temperature schedule shown in the table.

Temperature Range	Rate of Change of Temperature	Interval at Each Rate
A. Ambient to 140 °C	4.9 °C Per Hour	24 Hours
B. 140 °C to 160 °C	5 °C Per Day	4 Days
C. 160 °C to 165 °C	1.5 °C Per Day	3.3 Days
D. 165 °C to 185 °C	5 °C Per Day	4 Days
E. 185 °C to 250 °C	10 °C Per Day	6.5 Days
F. 250 °C to 500 °C	20 °C Per Day	12.5 Days
G. 500 °C to 550 °C	25 °C Per Day	2 Days
H. 550 °C to 700 °C	50 °C Per Day	3 Days
I. Hold at 700 °C		3 Days
J. Cool to Ambient		24 Hours

Slow, Carefully Controlled Heating according to a schedule based on the thermochemical properties of polyvinylidene chloride is necessary to obtain reproducible disks of microporous carbon.

cent included hydrogen, nitrogen, and such impurities as sodium chloride.

This work was done by Lakshmi V. Munukutla and Mark R. Moore of Arizona

State University for NASA's Jet Propulsion Laboratory. For further information, Circle 21 on the TSP Request Card. NPO-18238

Making Porous Zirconia for Heat Pipes

The material can be used to make sintered porous wicks.

Lyndon B. Johnson Space Center, Houston, Texas

A batch composition and processing schedule was developed to produce a porous zirconia that has a bubble point between 10 and 20 psi (70 and 140 kPa). The porous zirconia is used to make wicks for heat pipes.

First, a zirconia powder that contained 6 mole percent yttria and had a surface area of 10 to 15 m²/g, was calcined by heating in air at 1 °C/min to 1,200 °C and holding for 5 h. The calcined powder was

then sieved through a 120-mesh screen.

Next, 50 to 60 weight percent of as-received zirconia powder was combined with 40 to 50 weight percent of the calcined, sieved zirconia powder. The blended powder was added to an organic carrier (i.e., binder material) to obtain an overall composition that included 50 to 60 volume percent solids. These materials were mixed in a high-energy shear mixer until the mixture was uniform.

Sheets were then formed by passing the mixture through a two-roll mill. For bubble-point measurements, disks of 1-in. (2.5-cm) diameter were punched from sheets approximately 0.030 in. (0.076 cm) thick. Sheets about 0.1 in. (0.25 cm) thick were used to make tubular heat-pipe wicks.

The sheets and disks were placed in an oven and heated slowly in air to a temperature of about 800 °C to remove the binder. The parts were then heated in air at 100 °C/h to 1,400 °C, held at 1,400 °C for 5 h, and cooled to room temperature at 100 °C/h. The resulting sintered plate was cut and machined to form halves of tubes of D-shaped cross section. Pairs of halves were cemented together by use of a commercial zirconia-based cement to make 10-in. (25-cm) long tubes of porous zirconia (see figure).

This work was done by Felix Liu, James Guiheen, and James Van Ackeren, of Allied-Signal Aerospace Co. for Johnson Space Center. For further information, Circle 25 on the TSP Request Card. MSC-21872

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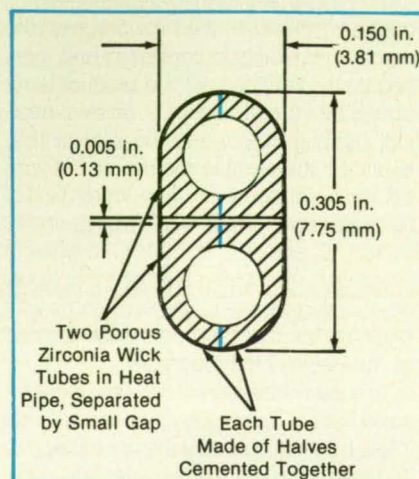
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Tubes of D-Shaped Cross Section were made of porous zirconia by use of the composition and process described in the text.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Electrical Conductivity of Diamond up to 1,200 °C

Results include first measurements of natural diamond and diamond films above 700 °C.

A report discusses measurements of the electrical conductivities of two syn-

thetic diamond films, three synthetic diamondlike films, and two natural type IIa diamonds at temperatures from ambient to 1,200 °C. The measurements were performed to compare the electrical conductivities of state-of-the-art diamond films with those of natural insulating diamond, particularly at temperatures above 700 °C, where no prior data existed. The development of high-temperature thermoelectric and thermionic energy-conversion systems depends on the concomitant development of electrical insulators that exhibit high thermal conductivities, that are stable at temperatures up to at least 1,000 °C, and that do not undergo electrolysis. Diamond films synthesized by plasma-enhanced controlled vapor deposition, like those tested, appear to offer the most promise of meeting these requirements.

The measurements were made with a specimen holder and oven that were constructed for the purpose. The holder was made from alumina. Wiring feedthroughs and connections were designed to minimize leakage currents bypassing the specimen. In this apparatus, the lower limit of conductivity measurements is about 10^{-16} to $10^{-17} \Omega^{-1} \text{ cm}^{-1}$.

The resistivities of each specimen were measured perpendicularly through the plane of the specimen by use of a direct-current, two-probe method with a guard ring and volume guard. Initially, niobium or graphite electrodes, variously, were sputtered on the specimens, but that approach was abandoned after it was discovered that the electrode materials migrated all over the specimens at high temperatures. Consequently, the conductivities measured during cooldowns were greater than those measured while the temperatures were increasing. This deficiency was overcome by changing to pressure contacts, and platinum foils were placed between specimens and niobium electrodes to prevent the formation of niobium carbides. With pressure contacts, the conductivities measured during heatup and cooldown were identical.

Although the electrical conductivities of the two synthetic diamond films were as much as hundreds of times that of natural diamond at room temperature, they were equal to or slightly less than the conductivity of natural diamond at temperatures of 800 to 1,200 °C. These results suggest that if synthetic diamond films could be made essentially free of defects, they would probably exhibit conductivities even lower than that of natural diamond.

The two synthetic diamond films (50 μm thick on molybdenum, and 6 μm thick on silicon, respectively) retained their diamond nature after exposure to 1,200 and 800 °C, respectively, and remained well

bonded to their substrates. At those temperatures, the conductivities of these two specimens were approximately 3×10^{-5} and $4 \times 10^{-6} \Omega^{-1} \text{ cm}^{-1}$, respectively. Activation energies calculated from the conductivities of the two synthetic diamond films as functions of temperature were found to be 1.8 eV and 0.9 eV, respectively. The activation energies of the type IIa natural diamonds, calculated in a similar manner, were both 1.4 eV, in substantial

agreement with prior values of 1.4 to 1.6 eV for type-I natural diamonds.

This work was done by Jan W. Vandersande and Leslie D. Zoltan of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "High Temperature Electrical Conductivity Measurements of Natural Diamond and Diamond Films," Circle 17 on the TSP Request Card. NPO-18396

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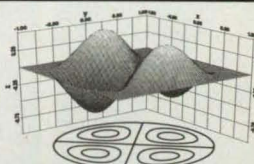
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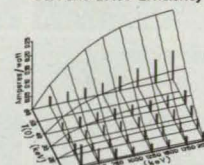
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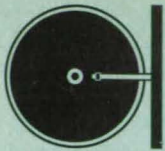
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Electronic Components and Circuits

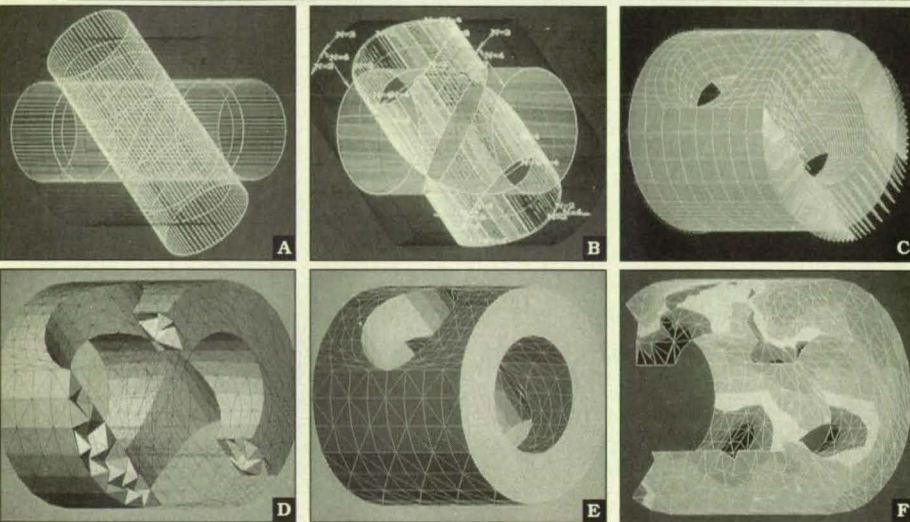
Scattering-Matrix Program for Circular Waveguide Components

Step discontinuities, corrugated sections, and horns can be analyzed.

Accurate computer modeling of passive circular waveguide components is often required in designing them for optimum frequency response and/or determining the tolerances required of them to meet radio-frequency specifications. Many circular waveguide devices can be represented either exactly or approximately by series of circular waveguide sections that have common axes. In addition, smooth tapers and horns of arbitrary profile can be approximated by series of small steps. The Scattering Matrix Program for Circular Waveguide Junctions (CWGSCAT) computes the scattering matrices of a series of circular waveguide sections. These sections must have the same axis, but the radius and length of each section is completely arbitrary.

Devices that can be analyzed include a simple waveguide step discontinuity (like that used in a dual-mode horn), a stepped matching section, or a corrugated waveguide section with varying slot depth. Certain types of corrugated horns can also be analyzed with this program. The mathematical model used in the program accurately predicts the reflection and transmission characteristics of such devices, taking account of excitation in modes of higher order (if it occurs) and of multiple reflections and stored energy at each discontinuity.

For a device that is so large with respect to wavelength that many modes can propagate in it, one might need to compute the reflection and transmission properties of a mode or series of modes of higher order. Interactions that give rise to such modes are represented best by defining a scattering matrix for the device. The matrix can be determined by matching modes at each discontinuity. The results of the calculations for individual discontinuities are then cascaded to get the matrix for the entire device.



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CWGSCAT is written in FORTRAN to run on IBM computers and compatibles running MS-DOS. It requires 355 Kb of random-access memory. The standard distribution medium is a 5.25-in. (13.34-cm), 360K diskette in MS-DOS format. CWGSCAT was developed in 1987 and last updated in 1991. This program is a copyrighted work with all copyright vested in NASA.

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This program was written by Daniel J. Hoppe of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 86 on the TSP Request Card. NPO-18708



Physical Sciences

Calculating Flows With Interfering Shock Waves

The Equilibrium Air Shock Interference (EASI) program takes account of the dissociation of air molecules.

New research on such hypersonic vehicles as the National Aero-Space Plane (NASP) has raised concerns about the effects of interference of shock waves on various components of the structures of these craft. State-of-the-art aerothermal-analysis software is often inadequate to predict local flows and fluxes of heat in regions of extremely high velocity gradient and heat transfer; for example, where an Edney-type supersonic jet impinges on a surface.

EASI is a computer program that revives and updates older computational methods for calculating an inviscid flow field and the maximum heating from interference of shock waves. The program expands these methods to solve problems that involve the six shock-wave interference patterns on a two-dimensional cylindrical leading edge (representing, for example, the scramjet cowl of the NASP) with an equilibrium, chemically-reacting gas mixture.

The inclusion of gas chemistry enables the more accurate prediction of the maximum pressure and heating loads by accounting for the effects of high temperature on the mixture of gases that constitutes air. Caloric imperfections and dissociation of chemical species in hot air cause shock-wave angles, flow-deflection angles, and thermodynamic properties to differ from those calculated by a mathematical model of a calorically perfect gas. EASI contains pressure- and temperature-dependent thermodynamic and transport properties to determine rates of heating, and uses either

a calorically-perfect-air model or an 11-specie, 7-reaction-air model at equilibrium with temperatures up to 15,000 K for calculation of the inviscid flow field.

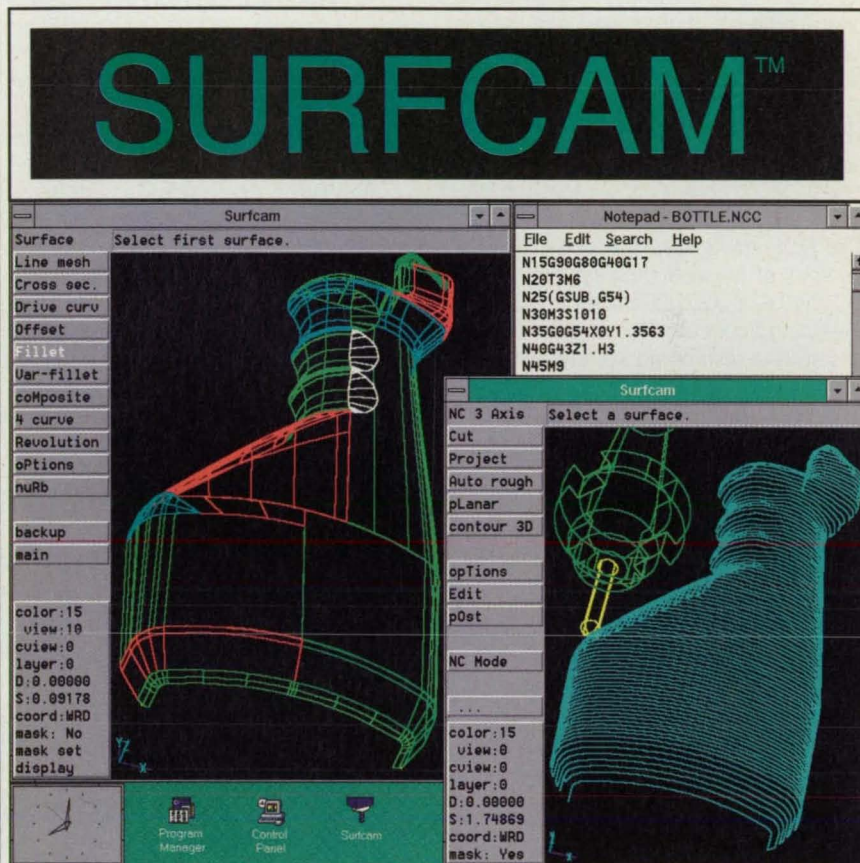
EASI solves for the flow field and the associated maximum surface pressure and heat flux for six types of shock-wave interference. Depending on the type of interference, the program solves for shock-wave/boundary-layer interaction, expansion-fan/boundary-layer interaction, attaching shear layer, or impingement of supersonic jet. Heat-flux predictions require a knowledge (from experimental data or relevant calculations) of a pertinent length scale of the interaction. Output files contain information on the flow field for the various

shock-wave interference patterns and their associated maximum predicted surface pressures and heat fluxes.

EASI is written in FORTRAN 77 for a DEC VAX 8500-series computer that uses the VAX/VMS operating system, and requires 75K of memory. The program is available on a 9-track, 1,600-bit/in. (630-bit/cm) magnetic tape in DEC VAX BACKUP format. EASI was developed in 1989.

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This program was written by Christopher E. Glass of Langley Research Center. For further information, Circle 60 on the TSP Request Card. LAR-14532



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Time Warp Operating System, Version 2.5.1

TWOS supports the parallel simulation of discrete events.

The Time Warp Operating System (TWOS) is a special-purpose computer program designed to support the parallel simulation of discrete events. TWOS is a complete implementation of the Time Warp software mechanism, which implements a distributed protocol for virtual synchronization based on the rollback of processes and the annihilation of messages. Version 2.5.1 supports simulations and other computations in which both virtual time and dynamic load balancing are used; it does not support general time-sharing or multiprocess jobs in which conventional message synchronization and communication are used. The program utilizes the underlying resources of the operating system.

TWOS runs a single simulation at a time, executing it concurrently on as many processors of a distributed system as are allocated. It is necessary to decompose the simulation only into objects (logical proc-

esses) that interact through time-stamped messages. TWOS provides transparent synchronization. The user does not have to add any more special logic to aid in synchronization, nor give any synchronization advice, nor even understand much about how the Time Warp mechanism works.

The Time Warp Simulator (TWSIM) subdirectory contains a sequential simulation engine that is interface-compatible with TWOS. This means that an application designer and programmer who wish to use TWOS can generate a prototype of code on TWSIM on a single processor and/or workstation before having to deal with the complexity of working on a distributed system. TWSIM also provides statistics about the application program that may be helpful in determining the correctness of that program and in achieving good performance on TWOS. Version 2.5.1 includes an updated interface that is not compatible with that of Version 2.0.

The TWOS user manual assists the simulation programmer in the design, coding, and implementation of simulations of discrete events running on TWOS. The manual also includes a practical user's guide to the TWOS application benchmark program Colliding Pucks.

TWOS supports simulations written in the C programming language. It is designed

to run on the Sun3/Sun4-series computers and the BBN "Butterfly" GP-1000 computer. The standard distribution medium for this package is a 0.25-in. (6.35-mm) tape cartridge in TAR format. TWOS was developed in 1989 and updated in 1991. This program is a copyrighted work with all copyright vested in NASA.

Sun3 and Sun4 are trademarks of Sun Microsystems, Inc.

This program was written by Steven F. Bellenot, John S. Gieselman, Lawrence R. Hawley, Judy Peterson, Matthew T. Presley, Peter L. Reiher, Paul L. Springer, John R. Tupman, John J. Wedel, Jr., Frederick P. Wieland, and Herbert C. Younger of Caltech for NASA's Jet Propulsion Laboratory. For further information, Circle 71 on the TSP Request Card. NPO-18692

PATSTAGS: PATRAN-to-STAGSC-1 Translator

Data from finite-element mathematical models are translated for use in other programs.

The PATSTAGS computer program translates data from a PATRAN finite-element mathematical model into STAGS (Structural Analysis of General Shells) input records to be used for engineering analysis. The program reads data from a PATRAN neutral file and writes STAGS input records into a STAGS input file and a UPPRESS data file. It can support translations of nodal constraints, and of nodal, element, force, and pressure data.

PATSTAGS uses three files: the PATRAN neutral file to be translated, a STAGS input file, and a STAGS pressure-data file. The user provides the names of the neutral file and the desired names of the STAGS files to be created. The pressure-data file contains the element-live-pressure data used in the STAGS subroutine UPPRESS.

PATSTAGS is written in FORTRAN 77 for DEC VAX-series computers running VMS. The main memory requirement for execution is approximately 790K of virtual memory. Output blocks can be modified to put out the data in any desired format, enabling the use of the program to translate model data to analysis codes other than STAGSC-1 (HQN-10967). This program is available in DEC VAX BACKUP format on a 9-track magnetic tape or TK50 tape cartridge. Documentation is included in the price of the program. PATSTAGS was developed in 1990.

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This program was written by Neil Otte of Marshall Space Flight Center. For further information, Circle 6 on the TSP Request Card. MFS-27262

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Theory of Damping in Composite Laminates

The effects of temperature, moisture, asymmetries, and anisotropies are included.

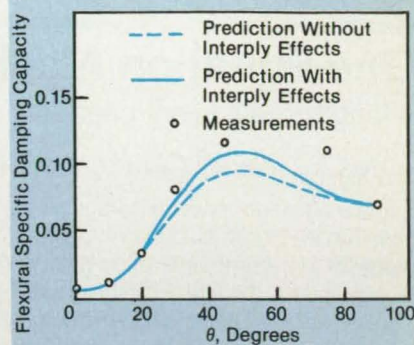
Lewis Research Center, Cleveland, Ohio

An integrated mathematical model predicts the vibration-damping properties of a laminated fiber/matrix composite material from the micromechanical level to the laminate level. The model is more generally applicable than prior models have been in that it accounts simultaneously for a wider, more realistic variety of laminate configurations and physical phenomena, including asymmetrically oriented plies, anisotropic fiber damping properties, hygral and thermal effects, and coupling among hygral, thermal, and mechanical effects.

The hygral/thermal/mechanical coupling is particularly important. Polymeric matrix materials are sensitive to variations in moisture and temperature. Because they tend to exhibit low thermal conductivities and high damping, they tend to heat up when vibrated for long times. In such cases, thermal and hygral loads affect vibrational characteristics, while vibrational responses can

induce thermal loads and thereby alter the laminate temperature.

The integrated mathematical model represents an extension, to composite angle plies and laminates, of a previous model for the in-plane and out-of-plane normal damping and the in-plane and out-of-plane shear damping of a composite ply. The previous (micromechanics) model included the effects of anisotropic dissipative properties, friction due to broken fibers, and hygrothermal effects on elastic and damping properties. In the integrated model, the specific damping capacity of a laminate is calculated from the damping contributions of the individual plies and of the interply damping layers between them. Fourier's heat-transfer law is used to solve the steady-state heat-transfer problem, including the effects of dissipation of vibrational energy within the composite and the transfer of heat to the environment. The interactions among the distribution of tem-



The Flexural Specific Damping Capacity of a $(\theta/\theta/\theta)$ angle-ply laminate (where θ is the ply angle) as a function of θ was predicted by the model and reported measured data.

perature, the hygral effects, and the mechanical properties in the case of steady vibrations is computed by an iterative scheme that converges rapidly.

The overall accuracy of the model has been demonstrated through various case

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studies and correlations with available measurements (see figure). These studies show that with the exception of longitudinal normal damping, the composite damping is controlled mainly by the matrix. Temperature and moisture appear to have significant effects on the matrix-controlled composite damping capacities. Off-axis damping was found to vary significantly with the ply angle, signifying wide margins for tailor-

ing damping. The laminate damping depends on laminate configuration, ply orientation, and loading. Variations in these parameters may dramatically change the damping of the laminate. The laminate damping was found sensitive to variations in temperature and moisture.

This work was done by D. A. Saravanos and C. C. Chamis of **Lewis Research Center**. Further information may be found

in NASA TM-102329 [N90-10185], "Mechanics of Damping for Fiber Composite Laminates Including Hygro-Thermal Effects."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15097

One-Equation Algebraic Model of Turbulence

A length scale is not needed.

Ames Research Center, Moffett Field, California

A one-equation model of turbulence is based on the standard equations of the k - ϵ model of turbulence, where k is turbulent energy and ϵ is the rate of dissipation of k . The derivation of the one-equation model was motivated partly by the inaccuracies of flows computed by some Navier-Stokes-equations-solving algorithms that incorporate algebraic models of turbulence. The one-equation model also satisfies a need to avoid having to determine algebraic length scales: in problems that involve multiple shear layers, the determination of algebraic length scales is cumbersome and unreliable.

The derivation of the one-equation model begins with the k - ϵ equations and with the definition of a turbulence Reynolds num-

ber, $R_T = k^2/\nu\epsilon$, where ν is the kinematic viscosity. By taking various combinations of the k - ϵ equations, omitting some terms, and making some approximations, one obtains an equation for the evolution of the field variable νR_T . This equation includes convective, source, and diffusive terms.

If certain terms in the equation for the evolution of k are neglected, this equation becomes a self-consistent mathematical model that should be a valid approximation over a major portion of a shear layer. In a test of its ability to predict flow near a wall, the model was calibrated on the basis of the well-established properties of the flow over a flat plate, and its predictions were compared with those of other models. As shown in the example of Figure

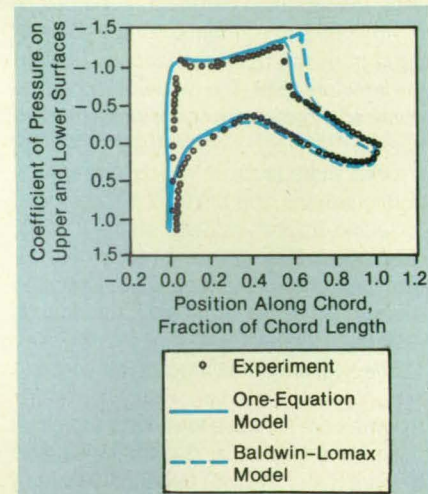


Figure 1. Coefficients of Pressure on an airfoil as predicted by use of two mathematical models of turbulence are compared with measured values.

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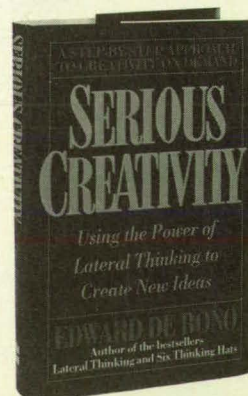
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1, the one-equation model performed better than did a prior algebraic model.

If certain other terms in the equation for the evolution of the field variable vR_r are neglected, this equation becomes a one-equation model for the evolution of R_r in free shear layers. Figure 2 shows the results of the application of this model to a self-similar wake flow, along with the corresponding prediction of a constant-eddy-viscosity algebraic model of turbulence and with data from an experiment. In Figure 2, u is the streamwise velocity, and u_0 is the value of u at the centerline.

This work was done by B.S. Baldwin and T.J. Barth of Ames Research Center. Further information may be found in NASA

TM-102847 [N91-10252], "A One-Equation Turbulence Transport Model for High Reynolds Number Wall-Bounded Flows."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-13127

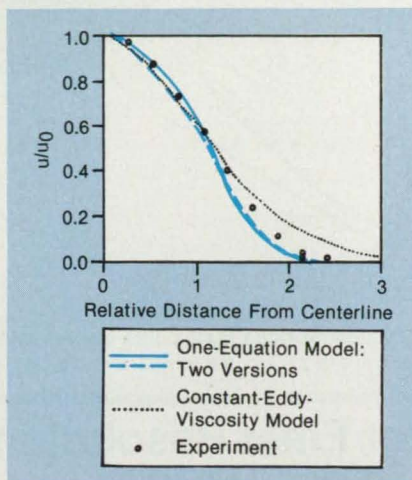


Figure 2. Values of u/u_0 in a Self-Similar Wake Flow as computed with the help of the one-equation and constant-eddy-viscosity models are compared with measured values.

Easy-to-Use Connector

Parts can be joined despite imprecise initial alignment.

Lyndon B. Johnson Space Center, Houston, Texas

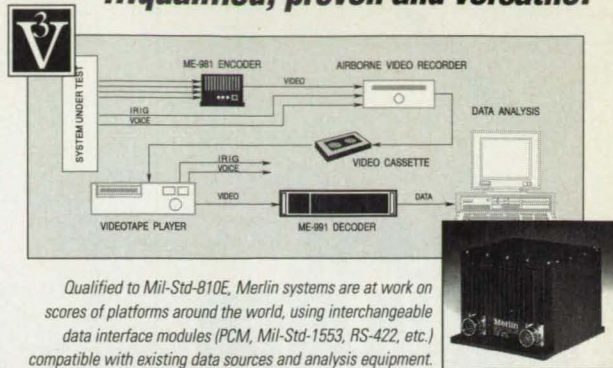
A quick-connect/disconnect mechanism consists of two mating assemblies that can be put together easily, even when they are initially misaligned by fairly large amounts. The mechanism can be used as an electrical- or fluid-connection interface. It can be operated by humans or robots when fast connections must be made without precise positioning -- for example, on offshore oil rigs, ship-to-dock links, nuclear facilities, and aircraft at loading gates.

The two assemblies are an approximately conical plug and a receptacle that contains a thick hexagonal-cross-section axial pin (see figure). As the plug is brought into initial contact and approximate alignment with the receptacle, its conical surface interacts with the mating surface of the receptacle to generate a torque that tends to align it axially with the receptacle. As the plug is inserted farther, the approaching mating surfaces interact to bring the plug and receptacle into alignment with respect to rotation about the axis of the cone. The interface can accommodate misalignments as large as 30° between the axes, $\pm 15^\circ$ in rotation about the aligned axes, and $1\frac{3}{4}$ in. (44 mm) in lateral translation. Once the plug is fully inserted, three latches on its periphery engage a groove in the receptacle, thereby securing the interface. Torque-reacting pins prevent the secured plug from turning about the disc. The interface can withstand a torque of 500 lb-ft (678 N·m) and a force at 925 lb (about 4.11 kN).

This work was done by William D. Wightman and Michael Gernhardt of Oceanerring Space Systems for Johnson Space Center. For further information, Circle 79 on the TSP Request Card. MSC-21945

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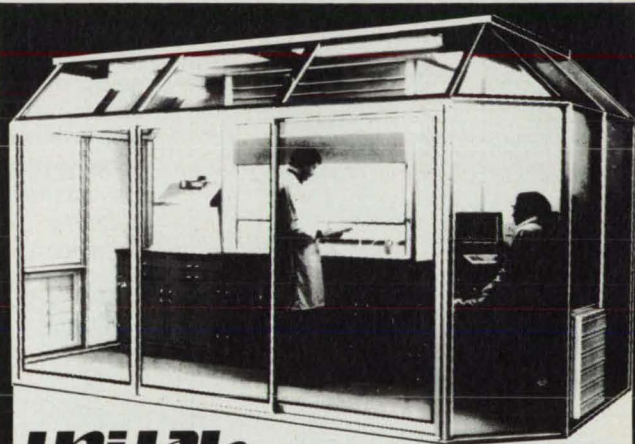
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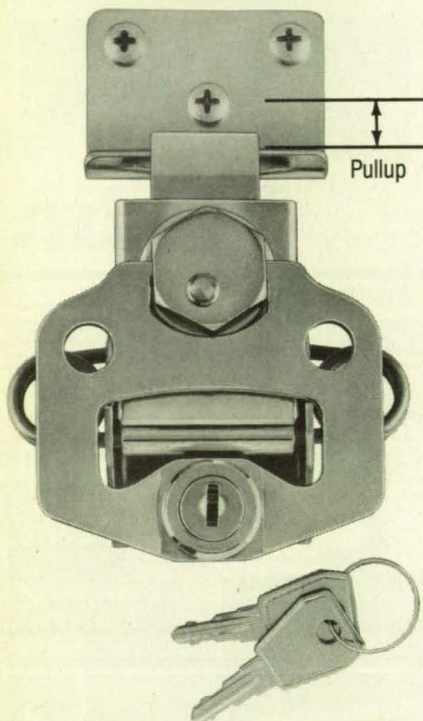
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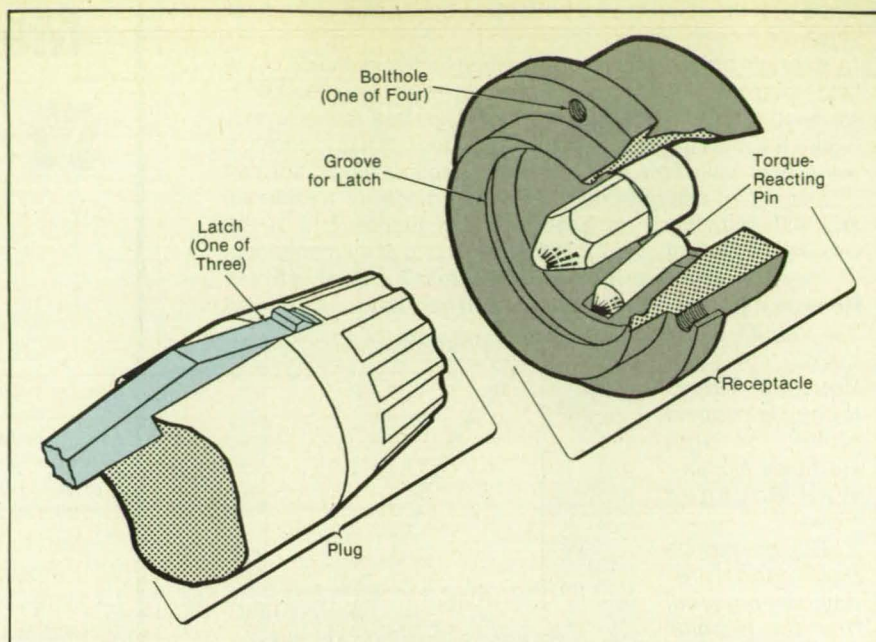
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Algorithm for Finer Resolution of Position of Shock

The position is resolved more finely than pressure transducers are spaced.

Lewis Research Center, Cleveland, Ohio

A proposed algorithm would compute the streamwise position of the terminal aerodynamic shock in the inlet of an engine of a supersonic airplane. Such an algorithm is needed because a signal representative of the position of the shock must be made available to the propulsion-control system of the airplane to ensure proper operation of the inlet.

A number of pressure transducers arrayed over the range of expected shock positions can be incorporated into the wall of the inlet. The location of the shock along the wall can be assumed to be that of the transducer that measures the minimum relative pressure (see Figure 1). In the absence of further processing of the measurements, the resolution of this method is

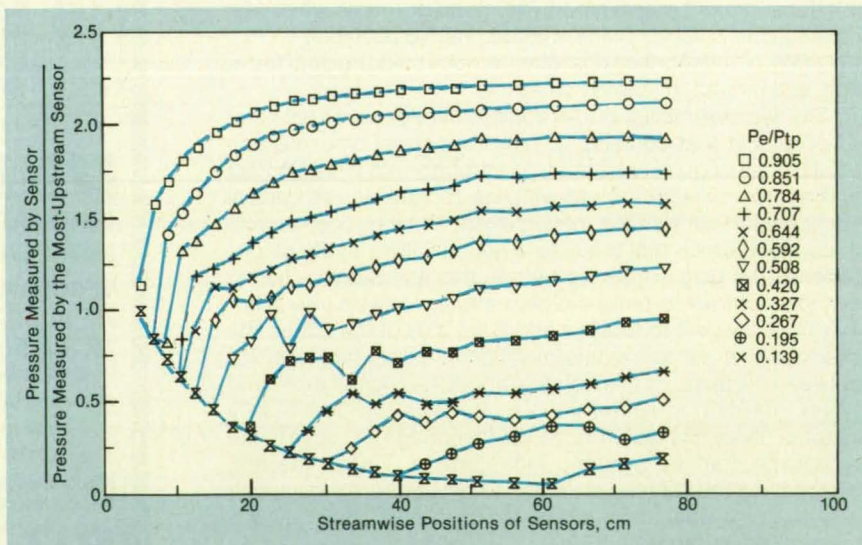


Figure 1. These Distributions of Normalized Pressure were measured in a supersonic inlet at various back pressures. The bottom curve is common to all distributions up to the point of minimum pressure, where the shock is located. (Note: P_e = exit static pressure; P_{tp} = inlet total pressure.)

limited to the spacing between transducers. While acceptable resolution could be achieved by use of many transducers, the cost and complexity of the system would be increased, and reliability would be reduced. The proposed algorithm would compute the position of the shock with a resolution much finer than the spacing between transducers and require neither an increase in the number of transducers nor any other change in the pressure-measuring equipment.

Before explaining the algorithm, it is necessary to explain the dependence of the pressure measured by any given transducer in the array upon the position of the shock (see Figure 2). If the shock lies upstream of the transducer and shifts downstream toward the transducer, then this pressure decreases. When the shock reaches the transducer, the pressure reaches a plateau and thereafter remains at the constant plateau value if the shock shifts further downstream. The pressure-vs.-shock-position curve for each transducer is determined by calibration measurements.

The proposed algorithm is based on the use of the nonconstant segments of the pressure-vs.-shock-position curves, each of which is unique to its transducer. In principle, one could use the pressure measured by any transducer downstream of the shock, together with the nonconstant seg-

ment of its curve, to compute the location of the shock. However, to obtain the most precise and reliable result, one should use the output of whichever transducer lies just downstream of the shock; that is, the upstream-most transducer that indicates a pressure above its plateau level. It is a straightforward task to devise an algorithm that can identify this transducer, then use its curve to compute the position of the shock.

The transducer-identification step of the algorithm would be equivalent to the relatively coarse determination of the location of the shock within a tolerance of one transducer spacing, as in the prior minimum-finding method. The algorithm could be made robust by requiring that the refinement in position computed by use of the curve lie within one transducer spacing of the transducer being used, or else the computed position would be deemed to be the coarse transducer position. The robust algorithm would thus yield a result at least as accurate as that of the prior minimum-finding method, even if the calibrations were incorrect.

This work was done by Miklos Sajben of McDonnell Douglas Corp. for Lewis Research Center. For further information, Circle 76 on the TSP Request Card. LEW-15167

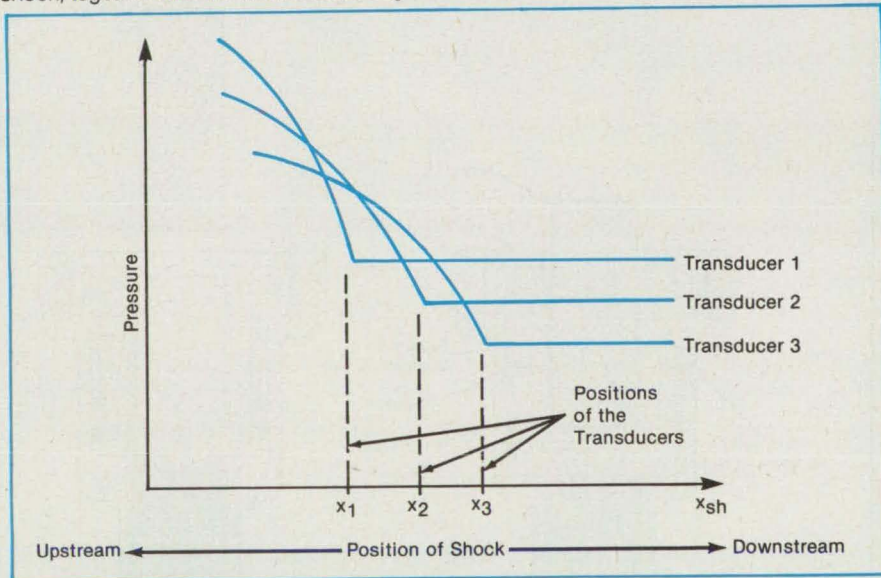


Figure 2. The Pressure Measured by Each Transducer varies with the position of the shock relative to the transducer.

Shape-Memory-Alloy Release Mechanism

This electrically activated mechanism would not have the disadvantages of pyrotechnic mechanisms.

Lyndon B. Johnson Space Center, Houston, Texas

A release-nut mechanism would be activated by electric current applied to a shape-memory alloy. Like a pyrotechnic release

mechanism, it would separate attached objects quickly by remote control. However, unlike pyrotechnic devices, it would

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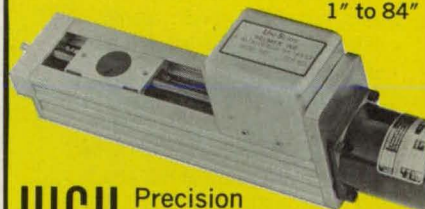
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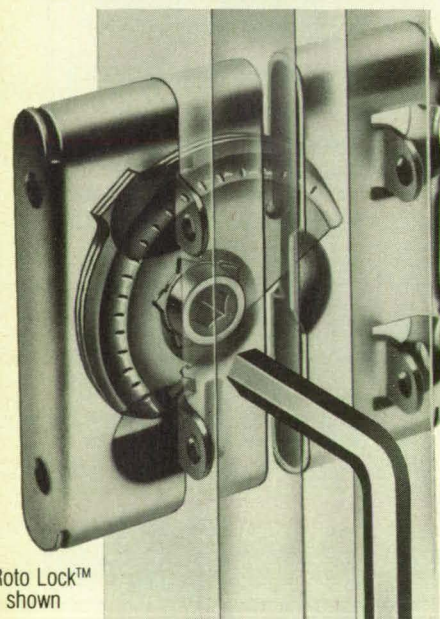
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not create a hazard or cause damage.

The release nut would be mounted in a housing that would also contain a piston, a hollow cylinder of the shape-memory alloy, and a heater inside the hollow cylinder (see figure). The nut would be segmented longitudinally. A shearpin would join each segment to the piston. A bolt on the attached object would be screwed into the nut.

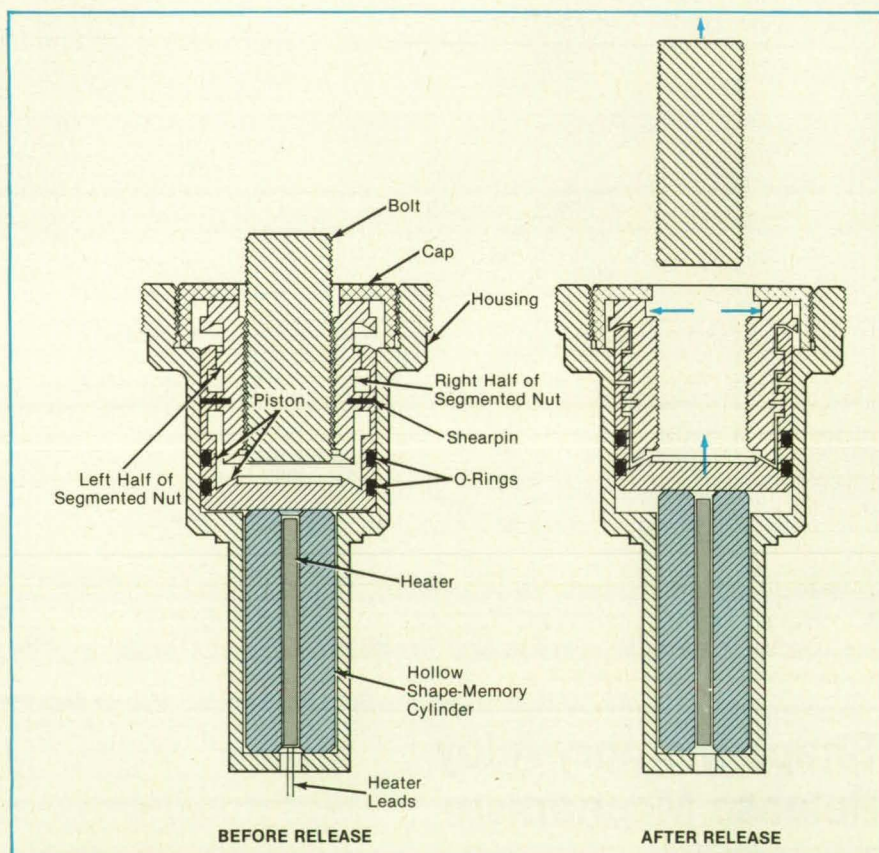
The shape-memory alloy, composed of nickel and titanium, can be bent, compressed, or otherwise deformed, and holds the shape thus produced until heated above a threshold temperature. It then returns to its original shape. The hollow shape-memory cylinder of the release-nut assembly would be compressed axially before insertion. To initiate release, an electrical current would be applied to the heater. The temperature of the hollow shape-memory cylinder would then rise above the threshold, causing the cylinder to elongate to its original length. In so doing, it would push against the piston. The upward motion of the piston would break the shearpins. After further upward motion, the ledges on the inner surface of the piston and the outer surface of the nut would clear each other. The segments of the nut would then be free to move radially outward to the limit of clearance of the ledges.

This outward motion would exceed the depth of the threads, so that the bolt would be freed from the nut.

Unlike pyrotechnic release mechanisms, the shape-memory release-nut mechanism would be unaffected by moisture or vacuum; it could be actuated underwater or in outer space. It would require a sustained current that would last 5 seconds or longer, and thus would be insensitive to electromagnetic interference. The mechanism could also be reused. The shape-memory cylinder could be recompressed and reinstalled in an assembly with new shearpins. With care, it could be used for thousands of release cycles. Moreover, unlike a pyrotechnic device, it would not create a shock that would disturb sensitive instruments, and it would not generate combustion products, high temperature, and pressure.

This work was done by Darin McKinnis of Johnson Space Center. For further information, Circle 73 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 22]. Refer to MSC-21935.



Before Actuation, shearpins would join the piston with the segments of the nut. During actuation, the hollow shape-memory cylinder would expand, severing the shearpins and creating room for the segments of the nut to move radially outward.

Generating Grids for Computing Flow in a Manifold

An established computer code is modified to apply it to complicated shapes.

Marshall Space Flight Center, Alabama

Grids for computing flows in a manifold of complicated shape have been generated by use of a modified version of the geometry module of the LWIND computer code. The manifold in question is the liquid-oxygen T-manifold of the main engine of the Space Shuttle, and the flows were computed in the effort to understand 4-kHz oscillations that are observed in practice. The modified grid-generating code can be adapted to other computations of flows in different geometries.

The simulation of flow in the liquid-oxygen T-manifold was performed by use of the FDNS fluid-dynamical computer code, which requires a three-dimensional mesh of grid points on each surface and in the interior of the flow volume. It would have been difficult to generate grids for the complicated T-manifold geometry by use of any of the previously available grid-generation codes. The modified grid-generating code was developed to represent accurately all the geometric features of the manifold in detail (see figure), and was designed to facilitate recomputation of grids for changed manifold geometries.

In modifying the LWIND grid-generating module, most of the generalized-geometry features of the code were replaced by equations that describe surfaces of specific parts of the manifold. Lines of intersections of surfaces (where parts fit together) were represented by solutions (algebraic or, where applicable, iterative) of the simultaneous equations that describe the intersecting surfaces. The body-fitted coordinates thus generated were blended trilinearly to generate interior grid points.

The code generates the Cartesian coordinates of each grid point and downloads

them to a data file for use by any applicable flow-simulating computer code. Because of the symmetry of the T-manifold, the code was required initially to generate only half of all grid points; the points of the other half could then be generated by making a mirror image of those of the first half.

This work was done by Peter G.

Anderson of SECA, Inc., for Marshall Space Flight Center. For further information, Circle 16 on the TSP Request Card.

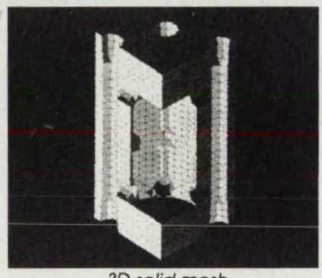
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 25]. Refer to MFS-26133.

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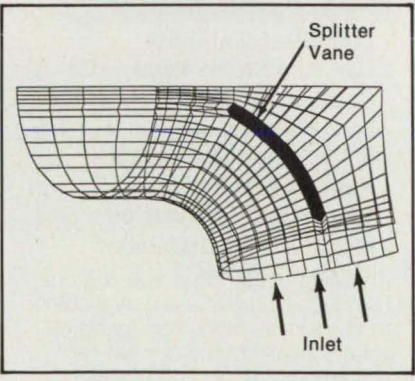
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For More Information Circle No. 446

Self-Aligning Mechanical and Electrical Coupling

Mechanical and electrical connections are secured with a single rotary actuator.

Goddard Space Flight Center, Greenbelt, Maryland

Figure 1 shows the two mating assemblies of a mechanical and electrical coupling. Like many other such couplings invented in recent years and described in *NASA Tech Briefs*, this one is designed to align itself and to be so easy to use that a robot can operate it.

Chamfers on the housing of the upper assembly and mating chamfers on the V-groove blocks of the lower assembly provide coarse initial alignment as the assemblies are brought into proximity. As the two assemblies are driven closer together, a splined rotary driver enters a mating splined cavity in a rotatable bolt in the lower assembly. Firm contact between the assemblies occurs when the rollers on the upper assembly settle into the V-grooves. The rollers and grooves taken together constitute a kinematic mount that assures precision alignment.

Immediately following initial soft contact between the assemblies, the lower end of the splined driver lies below an undercut in the splined cavity. The driver is rotated, thereby rotating the bolt via the spline connection. As shown in Figure 2, the bolt engages a large captive nut that is free

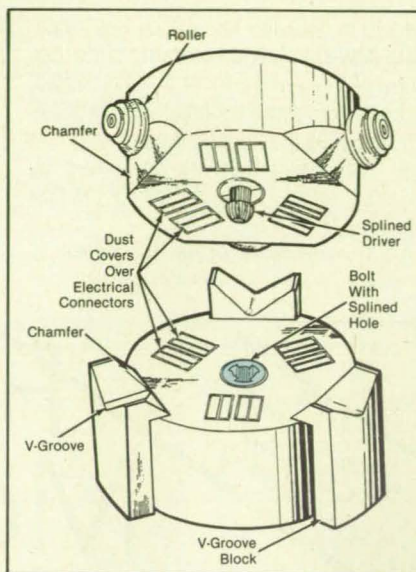


Figure 1. The **Rollers and V-Grooves** enforce the required alignment when the upper and lower assemblies are brought into firm contact.

to translate up and down but not to rotate; the bolt is also spring-loaded downward. The initial rotation in the direction of tight-

ening causes the bolt to move downward in the nut until the tops of the splines on the driver make contact with the undercut. This contact prevents further downward motion of the bolt. The spring force is now transferred via this contact to the upper assembly and provides a preload between the rollers and the V-grooves. Thus, the two assemblies are spring-preloaded in a kinematic clamp.

Further tightening rotation causes the nut to move upward. Male electrical connectors are mounted on the bolt, facing corresponding female electrical connectors in the upper assembly. Via cams and associated actuators (not shown in the figures), the upward motion of the nut causes dust covers over the electrical assemblies to open, exposing the electrical connectors. Continued upward motion brings the sets of mating connectors together. The disconnection sequence is simply the reverse of the connection sequence.

This work was done by John M. Vranish of Goddard Space Flight Center. For further information, Circle 92 on the TSP Request Card.

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For More Information Circle No. 488

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 22]. Refer to GSC-13430

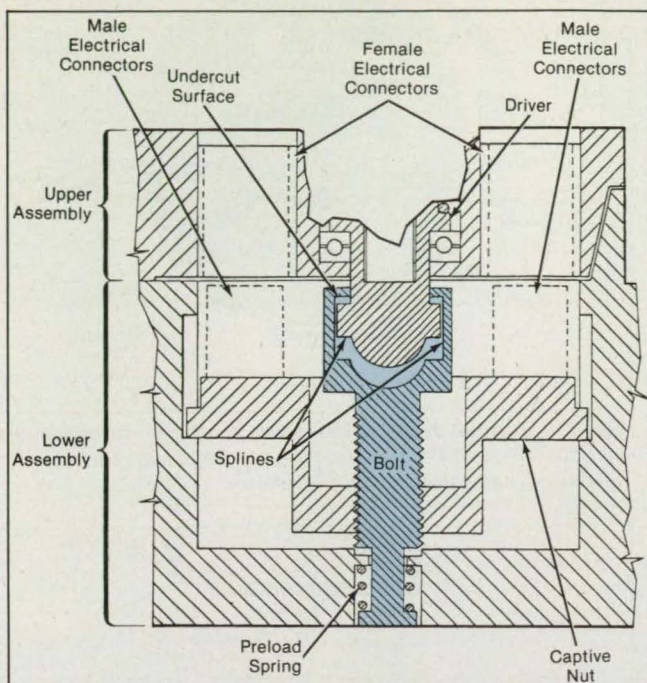


Figure 2. The Mechanism Inside the Lower Assembly provides spring preload between the two assemblies plus mating of electrical connectors, all actuated by rotation of the driver engaged with the bolt via splines.

Mechanism Guides Hatch Through Hatchway

The mechanism eases positioning on either side of the bulkhead.

Lyndon B. Johnson Space Center,
Houston, Texas

Figure 1 illustrates an approximately elliptical hatch designed to move through the hatchway to make a pressure-assisted seal with either side of the bulkhead. A compact three-degree-of-freedom mechanism guides the hatch through the hatchway or holds the hatch off to one side to facilitate the passage of crew and/or equipment. Hatches and mechanisms of this type could be used in submarines, pressure chambers (including hyperbaric treatment chambers), vacuum chambers, and vacuum-or-pressure test chambers.

Because of the pressure-assisted seal, the hatch cannot be opened accidentally until the pressure or vacuum on both sides is equalized. To prepare to move the hatch to the other side of the bulkhead, one first translates the hatch away from the bulkhead, then rotates the hatch about an axis perpendicular to its sealing plane to align its minor diameter parallel with the major diameter of the hatchway so that it can fit through the hatchway. After it has been passed through the hatchway, the hatch is again rotated about its own axis to align its major diameter with that of the hatchway. The hatch can then be translated and rotated into sealing contact with the bulkhead on the other side.

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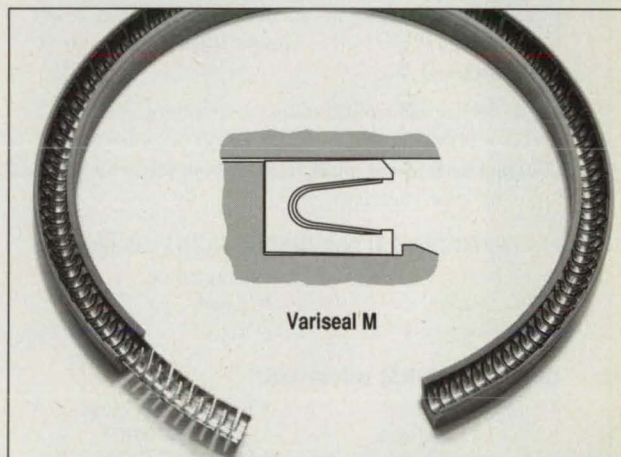
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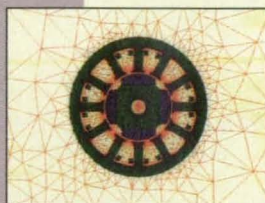
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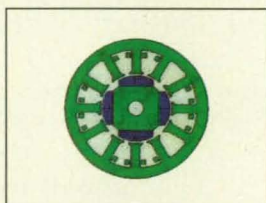


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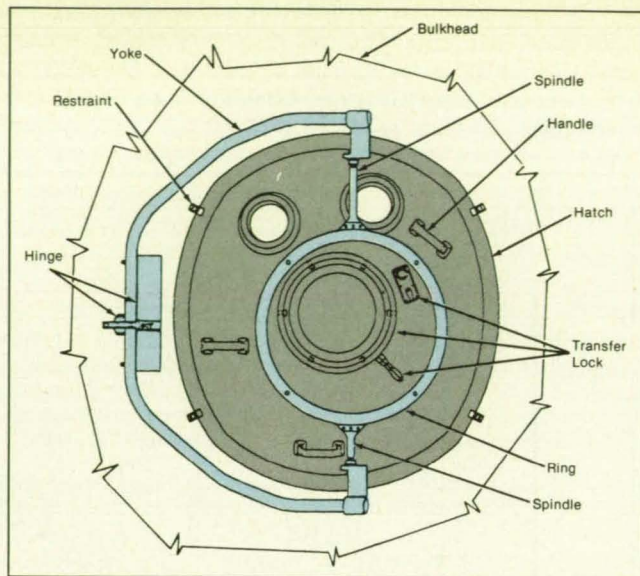


Figure 1. The **Hatch Is Equipped** with a guiding mechanism that includes an eccentrically mounted ring attached via spindles to a yoke, which is, in turn, attached to the bulkhead.

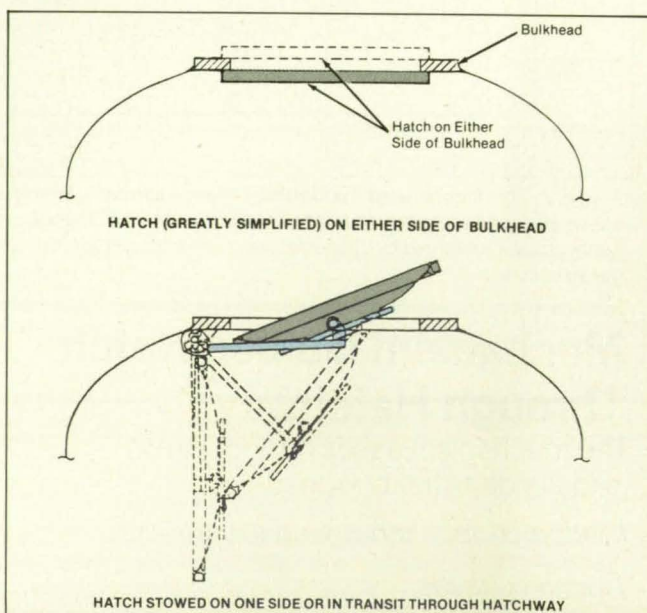


Figure 2. The **Hatch Seals to the Bulkhead** on either side and moves through the bulkhead under the guidance of the mechanism shown in more detail in Figure 1. All parts are shown here greatly simplified for clarity.

The alignment of major and minor diameters is effected by rotation of the hatch in the plane and about the axis of an eccentric ring on which the hatch is mounted. This ring is connected by a spindle to a yoke that in turn is hinged to the bulkhead. The eccentric mounting of the ring couples the rotation and translation of the hatch; this effect combines with the effect of the spindle-and-yoke configuration in such a way that the overall effect of the mechanism is to provide coupled rotations and translations that simplify the task of putting the hatch through the hatchway (see Figure 2).

This work was done by Daniel R. Barron and Steven E. Kennedy of McDonnell Douglas Corp. for Johnson Space Center. For information, Circle 15 on the TSP Request Card. MSC-218890

Estimating Conical Motion From Magnetometer Measurements

Parameters of motion would be extracted from band-pass-filtered measurements.

Marshall Space Flight Center, Alabama

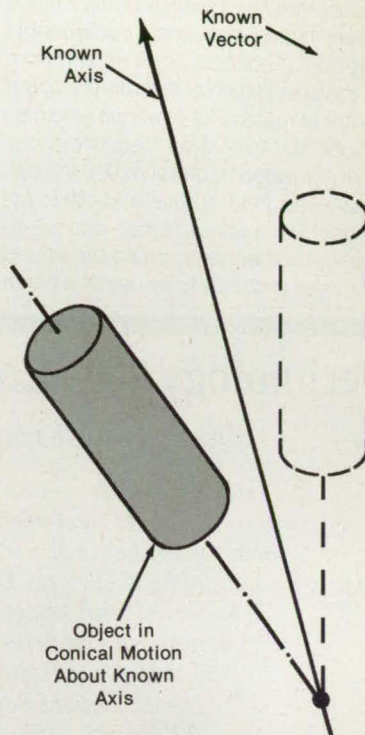
A proposed method of digital processing of the outputs of a magnetometer mounted on a scientific instrument or other assembly would provide estimates of the parameters of a slow oscillatory motion of the assembly at a constant or nearly constant frequency, in which motion one axis of the assembly (e.g., the optical axis of the instrument) describes an elliptical cone about a nominal fixed or nearly fixed axis (e.g., the nominal line of sight). The method was conceived for use in estimating the rotational-and-vibrational motion of a small instrumented satellite and a 20-km-long tether anchored at its lower end to the Space Shuttle. However, the method is applicable to almost any situation in which an assembly moves conically about a known axis while measuring a known vector (see figure).

In this case, the known vector is the magnetic field of the Earth at the known orbital position, as estimated from a mathematical model of the field. (In a terrestrial application, the magnetic field might be measured directly prior to commencement of the oscillatory motion.) From (1) the geometrical relationships among the axes

of the moving assembly, the axes of the magnetometer fixed to the assembly, and orbital coordinates, (2) simplifying approximations obtained by setting the cosines of small angles equal to 1 and the sines of small angles equal to the angles themselves, and (3) the further simplifying assumption that the cone described by the motion is circular, one can derive the basic equations of this method. These equations describe the oscillatory components of the magnetometer readings as sinusoidal functions of time and of the local parameters of the magnetic field.

Among other things, these equations show that one can deduce the angular amplitude (the half cone angle) and the phase of the motion from the amplitude and phase of the oscillatory component of the magnetic field along the moving axis that describes the cone. Similarly, one can deduce the frequency of the motion direct-

An Object Equipped To Measure a Known Vector oscillates slowly in conical motion about a known fixed axis. The amplitude, phase, and sense of the motion can be estimated from the band-pass-filtered measurements of the vector.



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ly from the frequency of the oscillation of the magnetometer readings and the sense of the motion (right- or left-handed circular) from the relative phases of the oscillatory components of the magnetic fields along the other two axes.

In the original spacecraft application, the magnetometer readings would include spurious, higher-frequency components arising from electronic sources and from pendulous oscillation of the satellite about its center of mass. The readings would also include spurious lower-frequency components generated by orbital motion through the magnetic field. In this and other applications, the spurious higher- and lower-frequency components could be filtered out in digital processing by use of a band-

pass transfer function that peaks at the nominal or assumed frequency of oscillation. In practice, one might have to "tune" the transfer function by performing iterative adjustments of the nominal frequency.

This work was done by M. E. Polites of Marshall Space Flight Center. Further information may be found in NASA TP-3123 [N91-25629], "A Scheme for Bandpass Filtering Magnetometer Measurements To Reconstruct Tethered Satellite Skiprope Motion."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. MFS-28641

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Distortion of Pressure Signals in Pneumatic Tubes

Effects of friction and reflection are represented adequately by a second-order mathematical model.

A NASA technical memorandum describes an experimental investigation of the distorting effects of the propagation of pressure signals along narrow pneumatic tubes from pressure-sensing orifices on the surfaces of models or aircraft to pressure sensors distant from the orifices. The pressure signals are distorted principally by frictional damping along the walls of the tubes and by reflections at the orifice and sensor ends. The distortions are important because they degrade the high-frequency responses of the sensors, thereby inhibiting the ability to measure rapid pressure transients.

This investigation included both laboratory and flight tests. In each case, the test procedure involved the comparison of the frequency response of a pressure-sensing transducer at one end of a tube to an acoustic signal of known pressure amplitude and frequency supplied by a transducer at the other end of the tube. In some laboratory tests, the effect of the decrease of pressure with altitude was simulated by partial evacuation of the tube-and-sensor plumbing.

Tests were performed at frequencies from 0 to 2,000 Hz on tubes with inside diameters from 0.021 in. (0.53 mm) to 0.125 in. (3.18 mm) and lengths from 0.35 ft (0.11 m) to 10.89 ft (3.32 m). All laboratory tests were performed at room temperature. The responses of the transducers were passed through a spectral analyzer, processed into polar form, and presented as plots of relative magnitude (input/output) and relative phase as functions of frequency.

The laboratory- and flight-test data were found to be in qualitative agreement. Both characterized the effects of attenuation (the result of friction) and resonance (the result of reflections). Quantitative disagreements between the laboratory and flight data are tentatively attributed to differences between ambient temperatures.

The data were analyzed in conjunction with a second-order-filter mathematical model derived from a one-dimensional wave equation. This model involves only two parameters: a damping ratio and a natural frequency that is a function of the lowest resonant frequency and the damping ratio. It was found that this model fit the data consistently.

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This work was done by Stephen A. Whitmore, Glenn B. Gilyard, and Robert Curry of **Ames Research Center** and William Lindsey of the Air Force Wright Aeronautical Laboratory. Further information may be found in NASA TM-4171 [N90-27703], "Experimental Characterization of the Effects of Pneumatic Tubing on Unsteady Pressure Measurements."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12868

Computations of Breakup of a Capillary Jet

Surface waves grow to pinch off large drops separated by smaller ones.

A report describes computations of the breakup of a round jet of liquid in a gas or vacuum. Such breakup occurs both spontaneously and when stimulated by vibrations that give rise to surface waves, some of which grow until drops pinch off. This phenomenon has been studied experimentally and theoretically for more than 150 years.

Of particular interest are two works by Rayleigh. In a theoretical small-perturbation linear stability analysis, published in 1879, he showed that all disturbances that have wavelengths greater than the circumference of the jet will grow. In experiments reported in 1896, he observed that when a jet breaks up, smaller drops form between the main drops. He called these smaller drops "spherules;" in the current terminology, they are called "satellite drops."

The present study focusses on the formation of satellite drops, taking advantage of advanced computers and computational methods to carry the theoretical analysis beyond the small-perturbation, linear regime. The liquid is taken to be incompressible, to be surrounded by a vacuum or by gas of negligible density, and to be inviscid. The flow is taken to be initially irrotational and to remain so.

Under these conditions, the flow can be represented by singular-dipole solutions of Laplace's equation distributed over the deforming surface of the jet. This is equivalent to generating the motion by use of a surface distribution of vortex rings of spatially and temporally varying density and to tracking the evolution of the surface via the motion of the dipole distribution.

The dipole density is determined so that the pressure at the surface, as determined from Bernoulli's equation, is balanced by the surface tension. The dipole density and the velocity potential on the surface are

related via a set of equations that include integrals over the deforming surface.

The equations are solved numerically on a computational grid that is attached to the deforming surface and that is fine enough to represent it accurately. The computations are carried out for a jet of infinite length subjected to various initial periodic disturbances. The initial growth of surface waves is found to agree with Rayleigh's analysis for the linear regime. When the computations are continued into the non-linear regime, the waves are found to pinch the jet off into large drops separated by satellite drops, the sizes of which decrease with decreasing wavelength. The computed sizes of the main and satellite drops

agree with experimental values.

Satellite drops are computed to form at all wave numbers in the regime of instability. The small satellite drops computed to form at wave numbers near the critical wave number are not predicted by linear and near-linear (up to third-order) analyses but are observed in experiments. Computations of the collapse of elongated satellite drops into shorter drops reveal short waves propagating along their surfaces.

This work was done by Nagi N. Mansour of **Ames Research Center** and Thomas S. Lundgren of the University of Minnesota. To obtain a copy of the report, "Satellite formation in capillary jet breakup," Circle 18 on the TSP Request Card. ARC-12848

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For More Information Circle No. 695



Supersonic Air-Breathing Stage for Commercial Launch Rocket

The payload can be increased 50 percent.

Langley Research Center, Hampton, Virginia

The Pegasus commercial launch rocket is launched from a B-52 subsonic airplane, and its three solid-fuel rocket stages place a payload of about 1,000 lb (about 450 kg) into orbit. The launch from the B-52 air-

plane is not very expensive because the airplane is reused for many flights. However, because the solid-fuel rocket stages are not reusable, the overall launch is expensive.

A concept has been proposed to expand the use of air-breathing, reusable stages to put more payload into orbit at less cost. A stage with supersonic air-breathing engines would be added to carry the expendable stages from the subsonic airplane to a supersonic velocity. The expendable stages would then carry the payload to orbit. To minimize aerodynamic drag, the expendable stages and payload would be placed in front of the supersonic air-breathing stage. After releasing the expendable stages, the remotely piloted supersonic air-breathing stage would return to the takeoff site and land for reuse.

Preliminary calculations for a typical design have been performed. The gross weight was held at 40,000 lb (about 18,000 kg), which is the gross weight of the Pegasus rocket. The size of the first solid-fuel rocket stage was reduced from that of the Pegasus to allow for the air-breathing stage, which includes an air-turbo-rocket engine. The expendable stages were considered to be released at mach 5. The results of the analysis indicate that the payload can be increased by 50 percent, to 1,500 lb (about 680 kg). The cost per flight might also be reduced because the size of the first solid-fuel rocket stage is reduced about 50 percent, although the sizes of the smaller upper stages would be increased about 50 percent. The analysis maintained the prior velocity contribution of the upper two solid-fuel rocket stages, which contribution may not be optimum.

The use of the B-52 airplane leads to a limitation on the weight of the expendable stages and, therefore, the weight of the payload. The new concept would extend the use of low-cost reusable hardware and at the same time increase the payload that could be delivered from the B-52. If one could use another subsonic airplane that can carry a greater launch weight, the new concept could also be applied to a launch from that airplane to obtain the delivery of greater payload than is possible in a system that includes only expendable solid-fuel rocket stages.

This work was done by James A. Martin of Langley Research Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 24]. Refer to LAR-14347.

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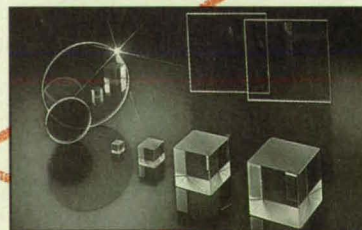
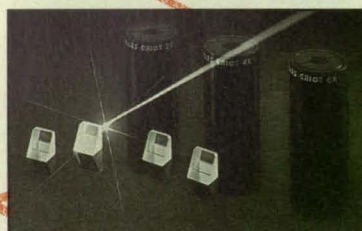
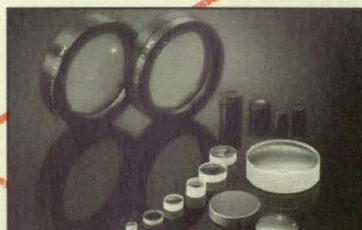
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Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Comparison of Force-Control Schemes for Robots

Different schemes are tested on the same robot in the same environment.

A report describes experiments in which several explicit force-control strategies for robotic manipulators were compared. Explicit force control, as distinguished from impedance control, involves the direct command and measurement of forces, with the goal of making a robotic manipulator follow the commanded force trajectory as closely as possible.

The following schemes were compared:

- Proportional gain with feedforward control,
- Integral-gain control,
- Proportional/derivative control, and
- Second-order low-pass-filter control.

The same robotic manipulator, sensor, and environment were used to compare these strategies. The primary tests were conducted with an environment consisting of a cardboard box with an aluminum plate resting on it. This simple environment has a predominantly linear, second-order behavior. However, its dynamics proved an adequate challenge to the control strategies, allowing discrimination of the best from the worst. The most promising and widely used of these strategies — integral and proportional gain control — were further tested on a very rigid steel environment.

The report concludes that, as predicted by analysis, force-trajectory tracking is best done with integral-gain explicit force control. It also concludes that proportional/derivative force control and damping strategies should not be relied on to provide stability to a robotic system in which the robot is in contact with the environment, because it is impossible to obtain a true derivative in such a system.

This work was done by Richard A. Volpe of Caltech and Pradeep Khosla of Carnegie Mellon University for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "An Experimental Evaluation and Comparison of Explicit Force Control Strategies for Robotic Manipulators," Circle 61 on the TSP Request Card.
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Tomographic Imaging of Low-Density Inclusions

Computed tomography shows details that are hidden in conventional radiography.

Marshall Space Flight Center, Alabama

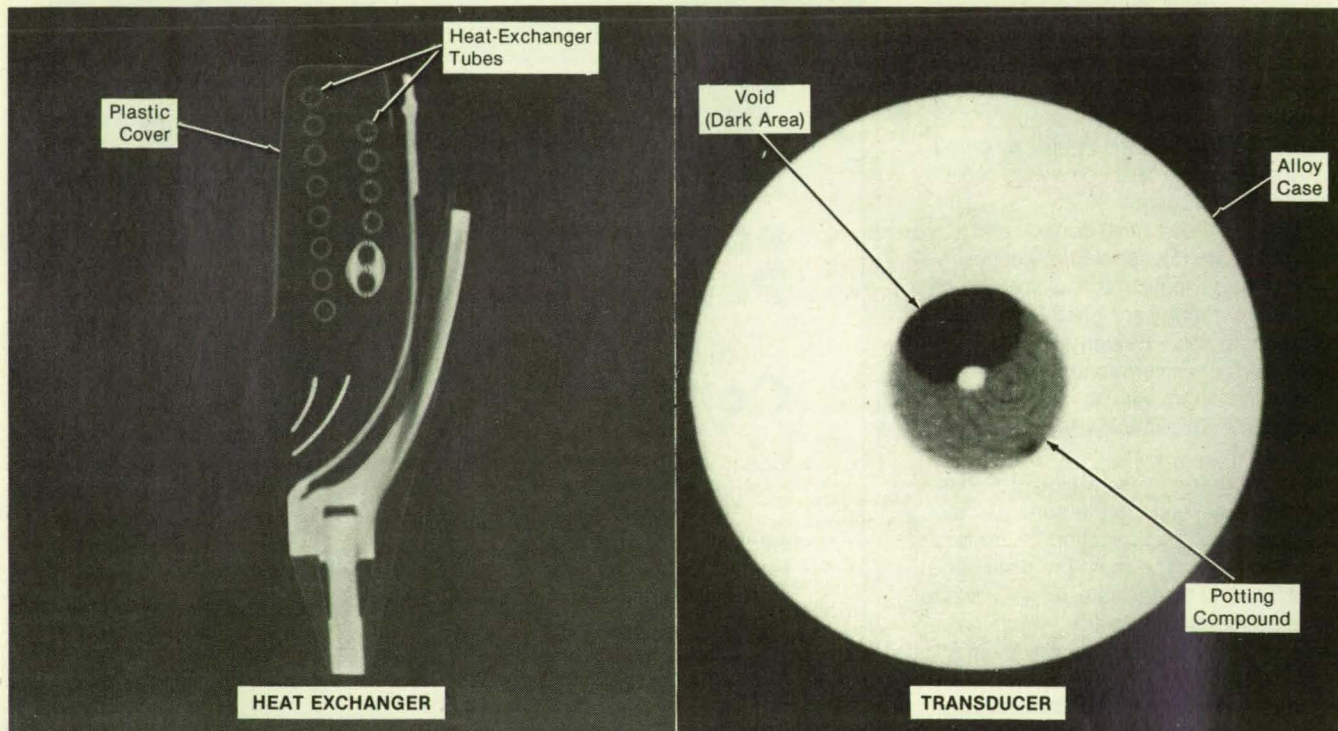
Computed neutron tomography can reveal the structure of a volume containing material of lesser density surrounded by material of greater density. In many cases, conventional x-radiography cannot probe less-dense materials hidden in more-dense materials, and conventional neutron radiography can do so only in the cases of certain combinations of enclosing and enclosed materials.

The computed-tomography technique

could be used, for example, to examine and measure flaws or other inclusions containing equally dense or less-dense material hidden in a complicated structure made of denser material. The technique has been demonstrated by using it to show a plastic protective guard within a heat exchanger made of Inco* 718 nickel-base alloy. It has also been used to show a void in a potting compound within the Inco* 718 case of a pressure transducer (see figure) —

a void that would seriously detract from the accuracy of data from the transducer. *"Inco" is a registered trademark of the Inco family of companies.

This work was done by Jagatjit Roy, Trung Nguyen, and James D. Willenberg of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available. MFS-29779



Materials of Low Density (including voids) that are hidden inside materials of greater density are often invisible in conventional x-radiographs. However, they are visible in these computed neutron tomographs.

Thin Hot-Film Sensors on Polyimide Film

These sensors are designed for nonintrusive detection of boundary-layer transitions.

Langley Research Center, Hampton, Virginia

The need to develop airfoils of higher lift and lower drag has prompted researchers to seek new tools to investigate the behavior of the boundary layer on the surface of an airfoil. To date, measurements of boundary layers typically have been made by use of pressure tubes and hot-wire probes, both of which intrude into the boundary-layer flow and exhibit relatively poor resolution.

An array of closely spaced hot-film sensors with a thickness well below the critical reference height with regard to the air-flow pattern could nonintrusively detect laminar boundary-layer transitions with very

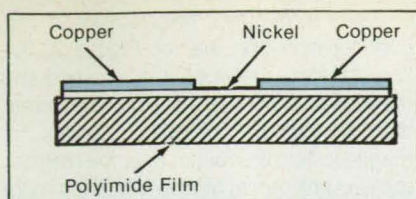
high resolution. A method has been developed at NASA Langley Research Center to fabricate such sensors on polyimide films to detect boundary-layer transitions with a resolution as high as 0.050 in. (1.3 mm). These films (see figure) are formed by a combination of vacuum deposition and photolithography.

First, the polyimide film is repeatedly cleaned ultrasonically in hot deionized water with biodegradable detergent and then transferred to a vacuum chamber for ion-beam cleaning in argon gas. During ion-beam cleaning, nickel of 99.99 percent or greater purity is evaporated onto the film

by electron-beam bombardment until the thickness of the nickel coat is 200 Å. Simultaneous bombardment by ions and evaporation of nickel are necessary to ensure good adhesion of the nickel to the polyimide. After bombardment by ions is stopped, evaporation of nickel is continued to the desired thickness, in this case, 2,500 Å. The design thickness of the nickel depends on the desired electrical resistance and geometry of the sensor.

After evaporation of nickel, and without breaking vacuum, copper of 99.99 percent or greater purity is evaporated to a thickness of 1,000 Å over the nickel deposit.

This layer of copper is a seed layer for further electroplating of copper. The copper is deposited over the nickel without breaking vacuum because otherwise a thin layer of nickel oxide would grow over the high-purity nickel, preventing other materials from adhering to the nickel surface. Additional copper is plated onto the evaporated copper to reduce the electrical resistance of the electrical leads. Then copper is plated onto the polyimide substrate by use of conventional plating processes employed in the manufacture of printed-circuit boards. The design thickness of the copper depends upon the intended application. Copper deposits for thin-film sensors fabricated thus far have been 2 to 5 μm thick.



Thin Films of High-Purity Nickel and Copper are evaporated onto polyimide film substrate.

Standard photolithography and wet chemical etching are used to define the sensor pattern. Photoresist is applied to the metalized film and prebaked in a convection oven. A contact exposure is made in the photoresist using an ultraviolet source, and the resist is developed. An etchant con-

taining deionized water, sulfuric acid, and hydrogen peroxide is used to define the nickel/copper sensor and electrical-lead patterns. A final etch of ammonium persulfate in deionized water and hydrogen peroxide is used to remove the copper from the nickel sensing element.

This work was done by Purnell Hopson of Langley Research Center. No further documentation is available.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14496.

Applied Magnetic Field Enhances Arc Vapor Deposition

The arc spot on the cathode moves in a more-controlled path.

Marshall Space Flight Center, Alabama

An applied magnetic field can enhance the performance of the vaporization part of an arc vapor deposition apparatus. In an apparatus of this type without an applied magnetic field, a direct-current (typically 10 to 100 \AA) arc is struck by touching an anode to a cathode in a vacuum chamber; then as the arc continues, the anode is pulled far enough away that, from the perspective of the cathode, the elec-

tric field of the anode blends in with the electric field of the plasma in the chamber (see Figure 1).

The arc touches the cathode in a spot about 10 μm wide. In this spot, the concentrated electrical current heats and vaporizes the cathode material, which is the material to be deposited on a substrate elsewhere in the chamber. Typically, the arc wanders randomly across the surface

of the cathode, with a superimposed overall motion toward the electrical feedthrough that supports the cathode. To prevent vaporization of the feedthrough material, the arc must be stopped, then restarted at the tip of the cathode by repeating the anode/cathode contact-then-withdrawal procedure.

In the case of a cathode material that is vulnerable to thermal shock (tends to break when subjected to a high gradient

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of temperature), localized heating by a slowly moving arc spot or by repeated striking of the arc in the same place can result in breakage. Sustained rapid motion of the arc can spread out the heating more nearly evenly over the cathode, thereby preventing breakage.

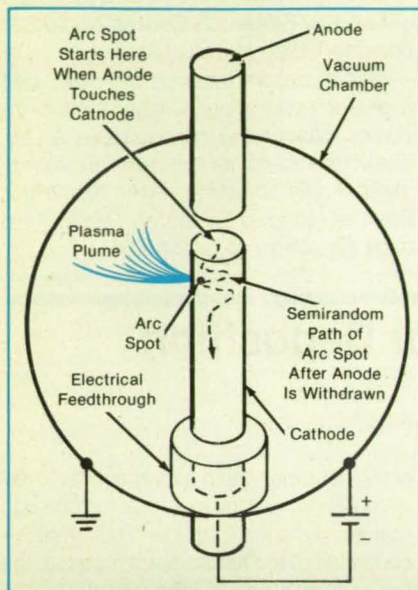


Figure 1. When No Magnetic Field Is Applied by external means, the arc wanders semirandomly over the cathode, with net motion toward the electrical feedthrough.

When a magnetic field is applied in a configuration like that of Figure 2, the Lorentz force between the arc and the magnetic field drives the arc circumferentially around the cathode. Because the magnetic field is stronger near the magnet, the circumferential motion becomes more rapid when the arc moves down the cathode. The combination of the circumferential motion and the gradient in the vertical component of the magnetic field results in an upward force that balances the tendency of the arc to travel downward.

Thus, the arc is made to move rapidly across the cathode, and it is not necessary to stop and restart the arc repeatedly to prevent it from reaching the electrical feedthrough. The magnetic field can be generated by an electromagnet, a permanent magnet, or both. The field generated by an electromagnet can be varied to move the arc up or down the cathode; this provides additional control over the otherwise partially random vertical motion of the arc.

This work was done by T. A. Miller, R. O. Loutfy, and J. C. Withers of Materials and Electrochemical Research Corp. for Marshall Space Flight Center. For fur-

ther information, Circle 7 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-26181.

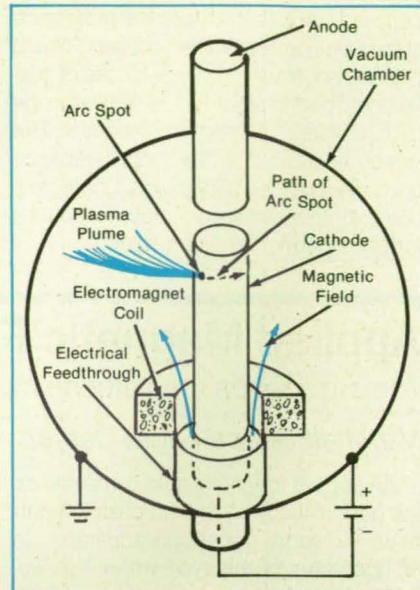


Figure 2. When the Magnetic Field Is Applied, the arc moves circumferentially around the cathode, and the downward motion is suppressed.

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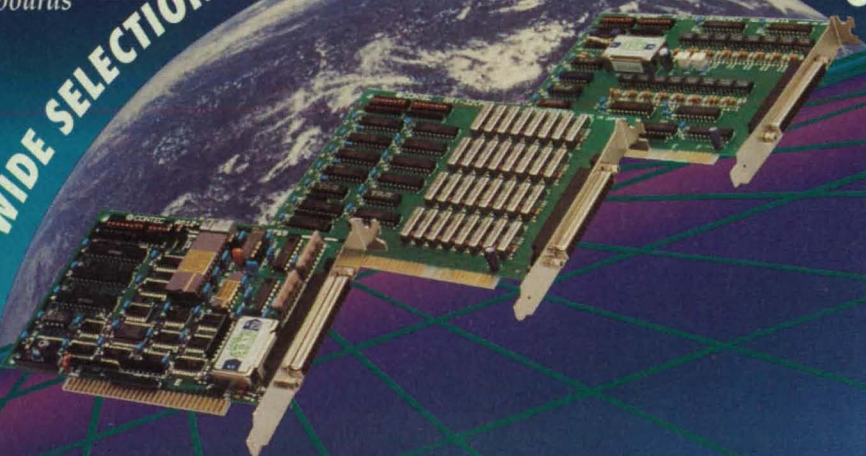
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Deflecting Shearpin

Spring loading helps to prevent permanent deformation of adjacent bearing surfaces.

Langley Research Center, Hampton, Virginia

A spring shearpin distributes a shear load nearly equally among a series of bolts in line with the load. In the usual bolted connection, the bolt closest to the load takes most of the load until the bolthole deforms enough to redistribute the load among the other bolts. In effect, a bearing-stress failure occurs at the bolthole nearest the load. The spring shearpin helps to prevent such permanent deformation and failure by deflecting.

In the worst case, when the maximum design load is exceeded, the spring shearpin acts like a standard shearpin to protect the structure if the load increases further. The pin can be used with static, dynamic, and thermal loads.

The shearpin (see figure) includes a spring, which is a cylinder with a single longitudinal slot cut in it. The spring fits inside a capture ring, which is a cylinder cut longitudinally into two pieces. A stud extends through the center of the spring and supports the parts. Screws hold the capture ring together.

The outer diameter of the spring is larger than the inner diameter of the capture ring. Thus, when the retaining screws are tightened, they compress the spring

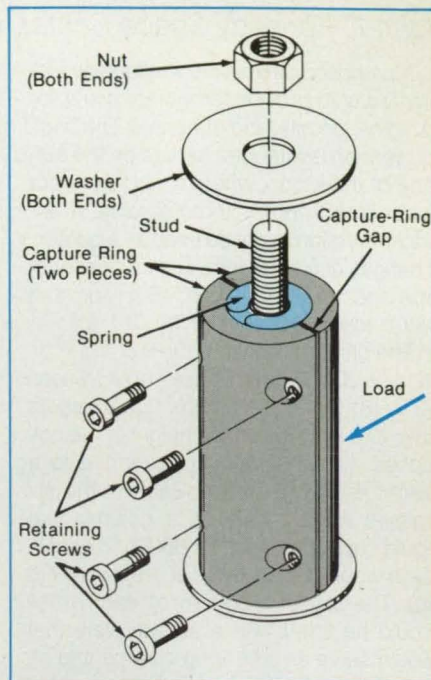
and preload the pin. This ensures that the pin will accept a minimum load before it deflects. The maximum deflection is determined by the size of the gap between the halves of the capture ring.

The sizes of the components are chosen to suit the application:

- The capture ring is designed to take the maximum allowable shear load.
- The spring is designed to provide sufficient preload.
- The screws are designed to withstand the preload force of the spring.
- The stud is designed for the expected tension load.
- The gap is sized for the tolerance between the hole and the pin so that only a limited amount of deflection can occur before the pin functions like a standard shearpin.

This work was done by Peyton B. Gregory of Langley Research Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14005.



The Shearpin deflects as a load compresses the inner spring. The maximum deflection is determined by the gap between the halves of the capture ring. Beyond that deflection, the pin acts as a standard shearpin.



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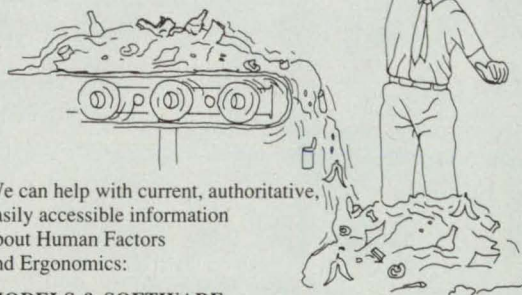
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Deployable Temporary Shelter

Compact storable components expand to create a large shelter.

John F. Kennedy Space Center, Florida

A proposed deployable shelter (see Figure 1) would provide temporary cover for vehicles, people, and materials. The original version is intended for use on the surface of the Moon, where it would protect spacecraft from micrometeoroids. A terrestrial version might be used as a garage, a hangar, or a large tent. The lunar shelter was sized to be 45 ft high, 45 ft wide, and 135 ft long (13.7 by 13.7 by 41.1 m).

The principal substructures of the shelter would include six deployable trusses 32 in. (81.3 cm) in diameter that measure only 10.4 in. (26.4 cm) in height in the collapsed state but can be extended to a height of 45 (13.7 m) ft. Each of the six trusses would serve as a column that could support a load of 1,660 lb (7.38 kN). Each would have a mass of 119 lbm (261.8 kg). The top and bottom of each truss would be fitted with a square plate that would serve as a bearing surface and attachment point for such other structural members as spacing and alignment bars and guy wires.

Blankets of protective material would be unrolled from large spools to form the roof and walls of the shelter. The roof blanket

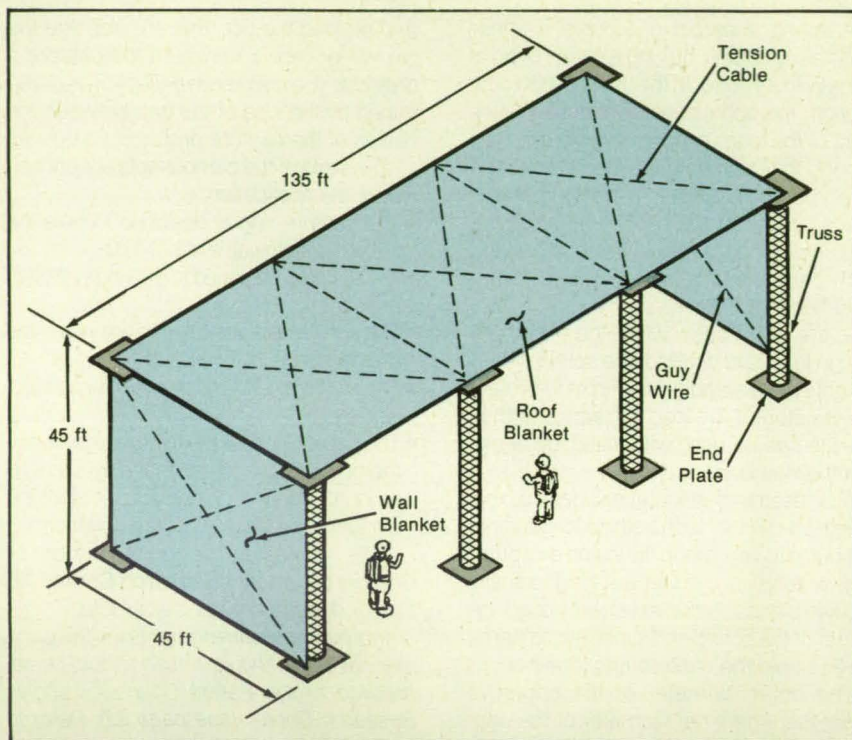


Figure 1. The **Fully Deployed Structure** would provide a large, unobstructed bay. The deployed trusses would support wall and roof blankets.

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would be attached to a network of tension cables between the tops of the undeployed trusses (see Figure 2). Rolled wall blankets would be attached to the top edge of the frame. The trusses would then be extended to full height. As the trusses would grow, they would draw the blankets from the rolls. The fully deployed structure would be reinforced with guy wires.

This work was done by Joe R. Shaffer

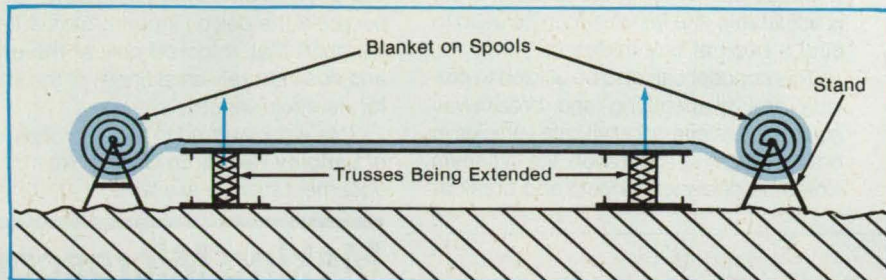


Figure 2. **Spooled Blankets** would be secured to the tops of the trusses before deployment. As the trusses are raised, they would draw the blankets along with them.

Composite Tiedown Fastener

A taut fastener is formed from flat tape and buckles.

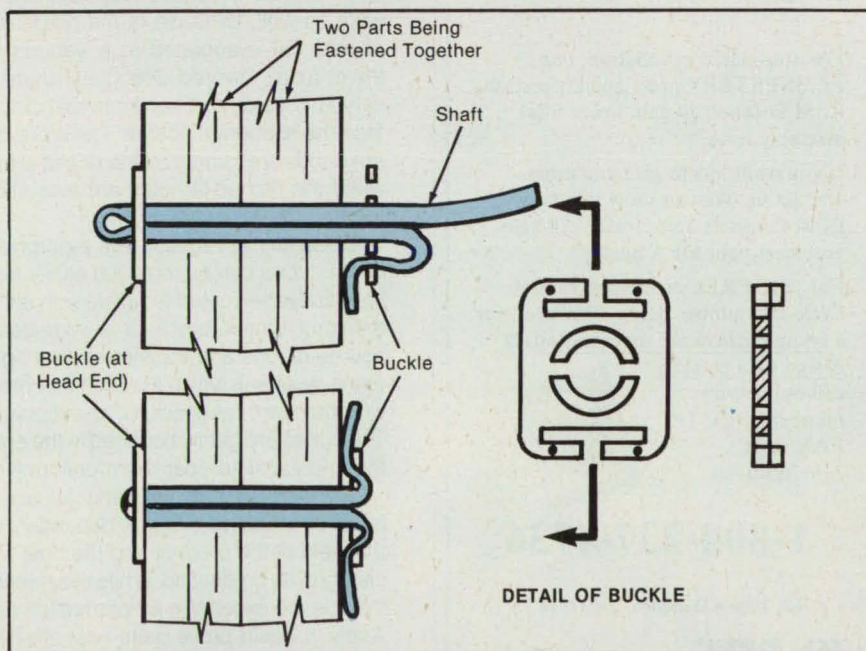
Langley Research Center, Hampton, Virginia

A novel, flexible, tiedown composite fastener for joining two or more material panels or other structural components can be dispensed from a roll and cut to the desired length. The fastener can be made partly of polyvinyl chloride or other resilient synthetic material and is designed for joining components for which snug all-around fits are required. The fastener can easily be installed and removed by hand without the use of tools.

The fastener includes a shaft that can be produced and stored in a rolled tape form and can easily be cut to length with

scissors or a knife. The fastener also includes a bucklelike head (see figure) that is of the same design as that of a tiedown buckle at the opposite end of the shaft. The use of the same design at both ends reduces cost and simplifies design and storage of parts.

The shaft is made from a thin strip of resilient synthetic or fiber composite material by forming the material into a semicircular cross section like the letter "C." The shaft is bent at its midlength, and its two ends are inserted and pulled through the two semicircular "C"-shaped holes in

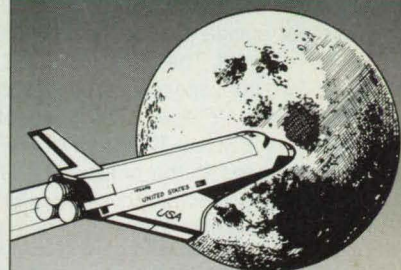


The **Shaft** is Cut To Desired Length, then fastened with buckles at both ends.

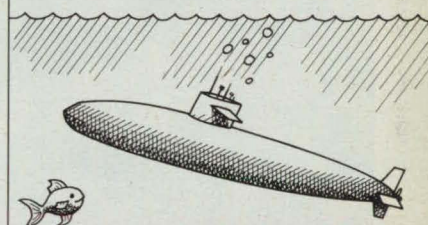
and David E. Headley of McDonnell Douglas Corp. for **Kennedy Space Center**. For further information, Circle 64 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center [see page 22]. Refer to KSC-11545.

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the head-end buckle. A taut fit is made between the shaft and buckle, thereby constructing a partially completed composite fastener with a head and a split hollow circular shaft.

The partially completed composite fastener is installed by pushing the as-yet unbuckled split-shaft ends through the holes in the components to be fastened. Then the other buckle is used to tie down the split-shaft ends. The buckle is a stiff, flat plate. Two opposite slotted holes shaped like the letter "T" are on each side of the semicircular holes. The stem of the "T" hole protrudes to the outer edge of the plate and provides an open slot for passage of the split-shaft ends. The buckle

could be metal, synthetic, or fiber composite material.

One use of this fastener is to bind pages and covers together to make a book. The flexibility of the fastener shaft allows the book to open wider than it otherwise could, and the snug fit between the shaft and the circular holes at the edge of the book keeps pages evenly spaced and aligned. Because the length of the fastener shaft is adjustable, the fastener can be used to bind a book of any thickness.

This concept can also be utilized to provide energy-absorbing and breakaway structural fasteners for fail-safe vehicles in crashes. For this application, the fasteners would be designed to yield and break at

the shafts or buckles at given loads. By fabricating the shaft and buckles out of nonmetallic composites, one could make fasteners of this type electrically or thermally insulating for use in electronics or scientific instrumentation, for example. Fasteners of this type could also be used as quick, inexpensive, structural tiedowns for shipping and handling of parts. Potential application extend to many areas because the design incorporates a flexible shaft that is locked only at the ends and does not rely on stiffness of the shaft for its effectiveness.

This work was done by Gim Shek Ng of Langley Research Center. No further documentation is available. LAR-14456

Making Microscopic Cubes of Boron

Fine particles are intended for use in solid rocket fuels and explosives.

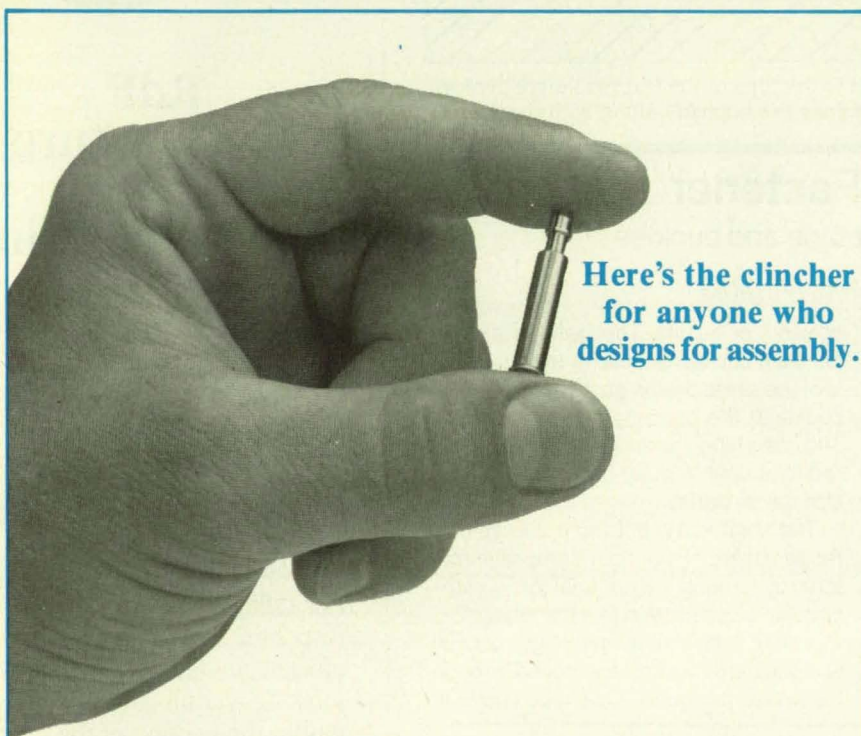
*Langley Research Center,
Hampton, Virginia*

The production of finely divided cubes of boron involves vacuum-deposition technology and requires the making of a template. This template (see figure) supports a pattern of checkered squares $25\text{ }\mu\text{m}$ on a side, which are etched $25\text{ }\mu\text{m}$ into the template material. The template is then coated uniformly with paralyene or some similar vacuum coating with a low coefficient of adhesion.

The template is then placed in a high-vacuum evaporation chamber and coated with boron to a thickness of $25\text{ }\mu\text{m}$. An electron-beam evaporator was used in experiments, but a resistive evaporator should work as well. Because of the propensity of material evaporated in a vacuum to travel along favored directions, there is very little coating of surfaces that do not face the evaporant source. Therefore, $25\text{-}\mu\text{m}$ cubes are formed on the raised areas, while the etched-in holes are also filled, forming $25\text{-}\mu\text{m}$ cubes in them.

While still in vacuum, the amorphous boron cubes can be removed easily from the paralyene-coated template with either a microfilament brush or a wide-beam source of ions and transferred to a sputtering system in which they can be coated with titanium, magnesium, or zirconium. The cubes are gently bounced in the sputtering plasma to coat them uniformly.

The viability of this material for use in a fuel or explosive is largely dependent on the yield of the product and the cost efficiency of its production. While this method may be too expensive for production currently, it could prove quite cost-effective as a production method in orbit around the Earth or on the Moon, where high vacuum is readily available. In addition to its intend-



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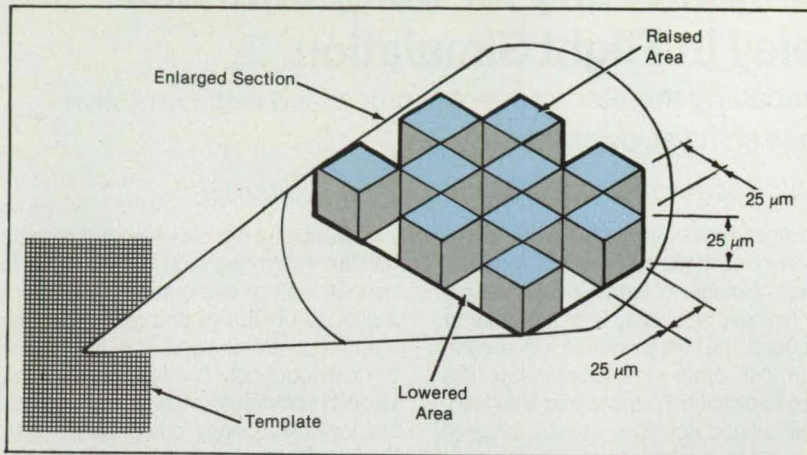
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ed application to solid rocket fuels, explosives, and pyrotechnics, this process could be used for many other applications, from manufacture of pharmaceuticals to processing of nuclear materials.

This work was done by Joseph M. Faulkner of **Langley Research Center**.

No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14260.



The **Surface of the Template** is a checkerboard of raised and lowered square areas. The lowered areas are the bottoms of cubic holes etched into the surface. The template is coated with paralyne.

Strain Gauges Mounted To Retain Calibration

A creep-proof bonding agent ensures stability.
Marshall Space Flight Center, Alabama

Silicon-based semiconductor strain gauges can be mounted in such a way that they retain the original calibration for several years instead of a few months. This improvement is effected by bonding the gauges to ceramic substrates with glasses instead of epoxies as the adhesives.

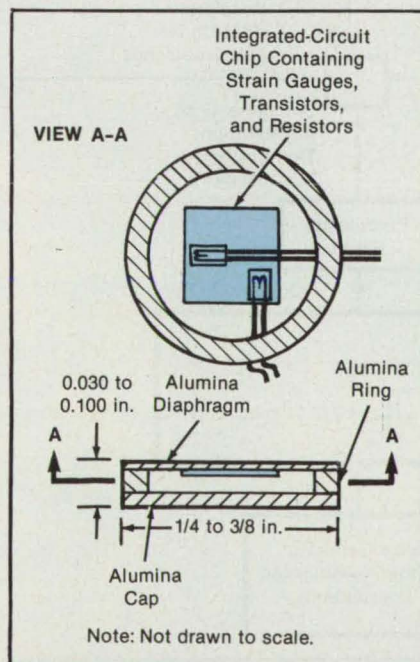
The reason for the improvement is sim-

ple: When a silicon gauge remains deformed under stress for a long time, epoxy creeps, allowing the stress in the gauge to change. This long-term creep makes an epoxy-mounted silicon gauge useless for tests that last more than a few months without calibration. However, the glasses that are used as the new bonding agents do not creep at the temperatures at which silicon-based semiconductor gauges operate. As a result, the strain gauges remain stable for years.

The figure illustrates a drum-type pressure gauge in which the transducers are strain gauges that are formed on a 0.2 by 0.2-in. (5.1 by 5.1-mm) silicon chip as parts of an integrated circuit that also includes temperature-compensating transistors and resistors. A low-temperature solder glass (melting temperature between 400 and 800 °C) bonds the silicon chip to an alumina diaphragm. A similar low-temperature solder glass bonds the diaphragm to an alumina ring and bonds the ring to an alumina cap. Thus, the gauges are hermetically sealed into the drum. The drum is embedded in the part to be tested.

This work was done by Barry L. Butler of Science Applications International Co. for **Marshall Space Flight Center**. For further information, Circle 3 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28625.



Silicon Strain Gauges are bonded by use of low-temperature-melting glass to the diaphragm of a short ceramic drum.

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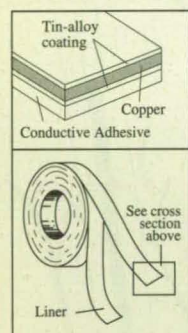
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For More Information Circle No. 535

3M Reveals New Long Term EMI/RFI Shielding Tape

Tin-alloy coating on both sides of copper foil offers superior solderability, environmental stability.

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The tape is a tin-alloy coated version of the widely used 3M 1181 Tape and provides shielding when wrapped around flat and round cable, and cable connectors.

The unique electrically-conductive adhesive enables 1183 tape to make electrical connections across

seams and between mating sections, of electronic enclosures ranging from small equipment housings to large shielded rooms. The tape can also shield the energy radiating from seams between the sectors of dish antennas.

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1. Thorough environmental stability and corrosion resistance.
 2. Exceptional solderability for applications such as sealing the seams when the tape is used as a shield around cable connectors.

3M 1183 Tape also serves as a corrosion resistant contact surface for conductive gasketing, beryllium copper "spring fingers" or other resilient conducting media used around doors and openings of electronic cabinetry.

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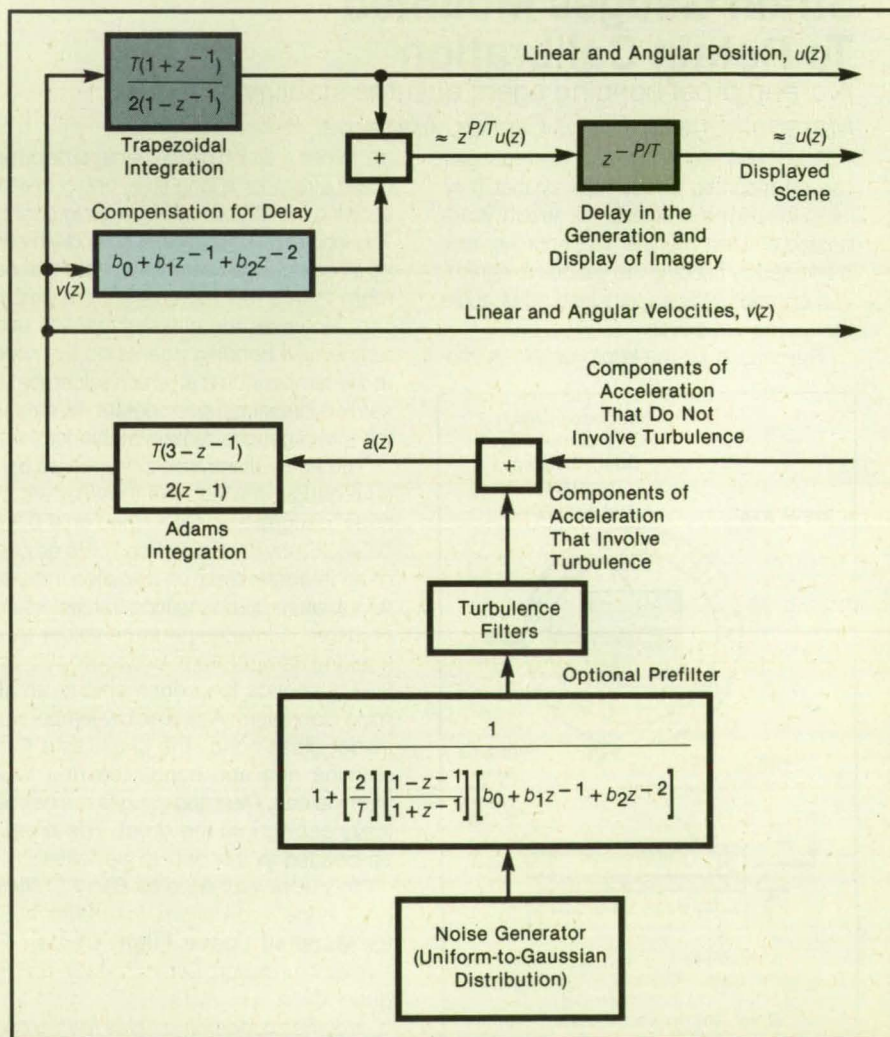
Compensating for Computational Delay in Flight Simulation

Computer-generated imagery is processed with corrective phase shifts at lower frequencies.

Ames Research Center, Moffett Field, California

An algorithm compensates partly for the delay involved in the computation and presentation of images of terrain in a flight simulator. Typically, this delay is of the order of 0.1 second; the pilot perceives it in accumulation with other simulation delays like analog-to-digital conversion and with faithfully simulated delays in the response of the aircraft to control actions. It is desirable to compensate for this delay to ensure that the simulated aircraft behaves like the real aircraft and to prevent degradation of the pilot's control capability.

Essential to the development of the algorithm was recognition that the upper frequency limit of changes in imagery that a pilot can perceive and respond to with manual control actions is of the order of 3 Hz. Accordingly, the algorithm was developed from transfer functions that predict the lower-frequency components of the response of the aircraft a short time into the future. The effects of the delay at these lower frequencies are counteracted by introducing compensatory phase shifts, opposite those caused by the delay, into the



The Delay-Compensating Algorithm, illustrated here as a filter with a z-transform transfer function, introduces a phase shift that compensates, at low frequencies, for the delay in the generation and display of imagery.

signals that drive the computer-generated imagery.

The algorithm functions, in effect, as a discrete-time compensation filter, which augments the discrete-time velocity-to-position integration that is performed in computing the response of the aircraft (see figure). The computations are performed in the z-transform domain because of its particular suitability for use with quantities sampled at discrete times. The velocity-to-position integration is performed by use of a trapezoidal-integration subalgorithm that, in itself, does not introduce any additional phase error.

The delay-compensating algorithm uses

three successive values of velocity to extrapolate the position of the aircraft P seconds into the future:

$$u_{k+P/T} = u_k + b_0 v_k + b_1 v_{k-1} + b_2 v_{k-2}$$

where $u_{k+P/T}$ and u_k denote the extrapolated position and the position at the present (k th) sampling period, T is the duration of a sampling period (typically, 20 to 30 ms), the other subscripts denote the successive sampling periods, and the v 's denote the velocities. The transfer function that represents this extrapolation is

$$f_A(z) = \frac{u(z)}{v(z)} = z^{-P/T} \left[\frac{T}{2} \left(\frac{1+z^{-1}}{1-z^{-1}} \right) + b_0 + b_1 z^{-1} + b_2 z^{-2} \right]$$

Suitable values of the parameters b_0 , b_1 , and b_2 can be obtained by use of associated constraint equations and by selection of a crossover frequency, which is essentially the upper frequency limit of effective compensation and is the frequency at which an associated relative-error transfer function $j\omega f_A(\omega T)$ (where ω = angular frequency) vanishes.

This work was done by Richard E. McFarland of **Ames Research Center**. For further information, Circle 90 on the TSP Request Card.
ARC-12269

Managing Inventory at a Transitional Facility

An inventory-management system helps a research facility prepare manufacturing.

John F. Kennedy Space Center, Florida

The Kennedy Inventory Management System (KIMS) is geared to the needs of a facility in transition from research and development to manufacturing. Operated jointly by several contractors at Kennedy Space Center, the KIMS is designed to reduce the cost and increase the efficiency of fabrication and maintenance of space-flight hardware.

In research and development, one cannot anticipate what materials will be required; therefore, a large inventory must be maintained. In a manufacturing environment, work is planned around a bill of materials, and items are acquired as they are needed.

One contractor uses the KIMS to track 45,000 line items in the base operations warehouse. Requirements for material are entered into the system as they are received. The KIMS generates pick lists, and the materials are retrieved and brought to a central staging area, where they are redistributed into kits for individual tasks. If picking reduces the stock of a given item below a preset minimum, the KIMS issues a purchase request automatically.

Another contractor, responsible for flight operations, uses the KIMS to track 40,000 line items of flight hardware and 100,000 line items of support and facility material. Yet another contractor, responsible for mission-related hardware, uses the KIMS to track 64,000 line items of inventory and 8,000 line items of equipment.

A fourth contractor uses a material-requirements-planning (MRP) system, which is implemented by use of highly modified

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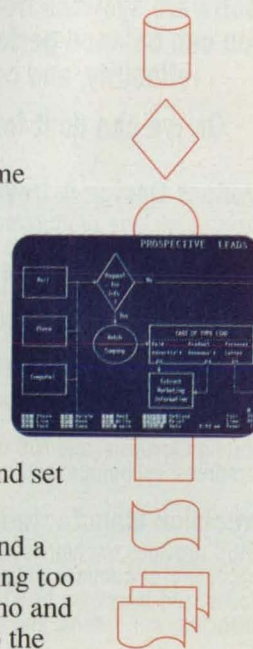
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Novell is a registered trademark of Novell, Inc.



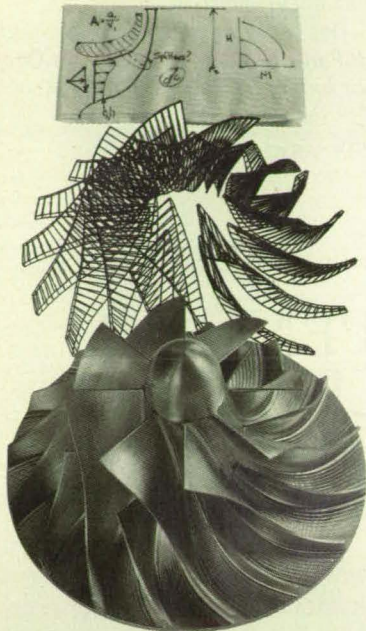
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commercial software. This MRP system helps to anticipate future needs, thereby assisting in planning to avoid shortages as well as to manage inventory. The MRP system also reduces the costs of inventory and cuts transportation costs by reducing the need for emergency shipments. The MRP system thus brings the Center closer to a full manufacturing environment.

This work was done by Henry A. Hutchins of USBI for Kennedy Space Center. For further information, Circle 8 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center [see page 22]. Refer to KSC-11530.

Flexible Weighting-and-Matching Scheme for Incomplete Data

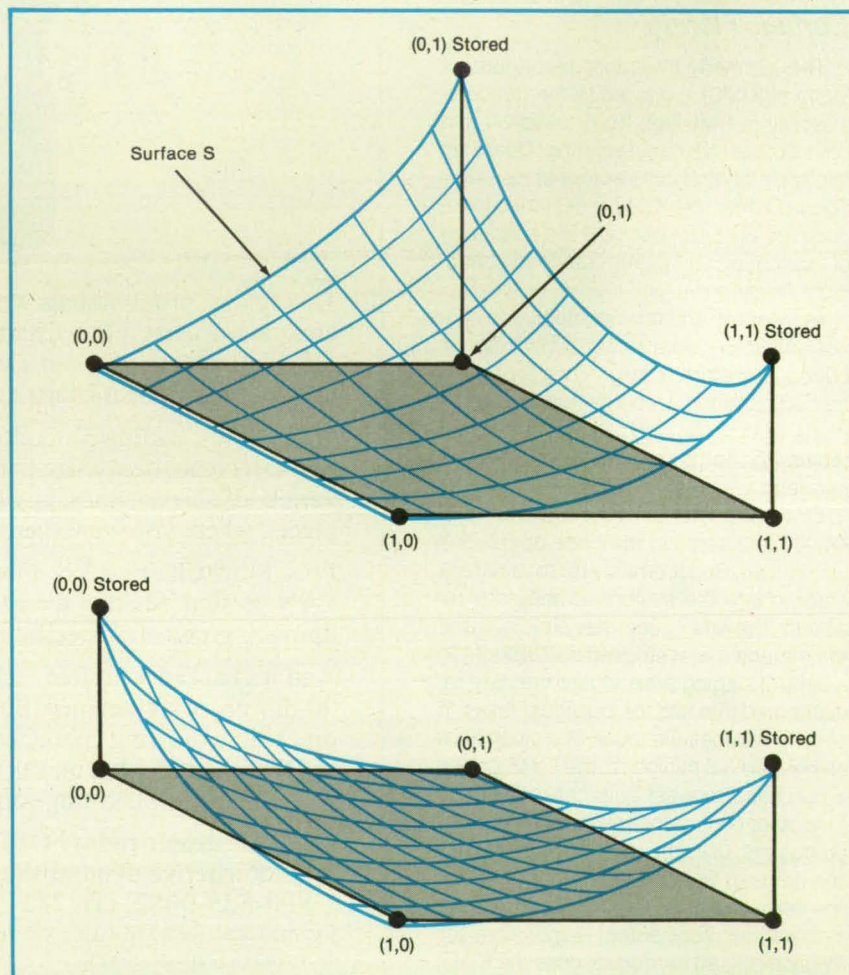
Responses include exact or approximate recollection, indications of ambiguity, avoidance, and even forgetfulness.

Lyndon B. Johnson Space Center, Houston, Texas

A method for the partial matching of data makes a conventional electronic memory addressable via its contents, somewhat like a biological memory. When implemented by a suitable algorithm, the method enables the computer system containing the memory to search the memory for the datum that makes the exact or the best (according to an objective function) approximate match to the datum in a query. The

new method offers advantages over previous artificial-neural-network methods: It requires neither long "learning" time nor "re-training" when additional data are stored and attaches to each datum a relative importance (i.e., a weight) that can change with time without decreasing the speed of retrieval.

Each datum — a sequence of n binary digits — is considered to be a lattice point,



A Three-Dimensional Space provides simplified examples based on the storage and retrieval of two-digit binary data. Surface S represents the weighting function. In the upper example, greater importance is attached to the stored datum 0,1 than to the stored datum 1,1, while the data 0,0 and 1,0 are ignored. In the lower example, the data 0,0 and 1,1 are weighted equally, while the data 1,0 and 0,1 are ignored.

each coordinate of which has the value 0 or 1, in an n -dimensional space. With the m th point B_m stored at time t , there is associated an integer $H(m,t)$ that represents its relative importance or weight. Each point is also characterized by an integer $Q(m,t)$ which is +1 if the point is to be sought, 0 if the point is to be ignored, and -1 if the point is to be avoided. Depending on input supplied by the user or by an algorithm, $Q(m,t)$ and $H(m,t)$ can change with time; for example, $H(m,t)$ can decrease if the system is programmed to discount or "forget" aging data gradually.

In an $n+1$ -dimensional space in which the data points are contained in an n -dimensional plane, a point is placed at a height $Q(m,t)2^{H(m,t)}$ above each datum B_m . These points are connected by a smooth surface, which also covers non-binary points (see figure). Thus, the surface S has peaks over points to be sought, falls to zero at points to be ignored, and de-

scends to valleys below the n -dimensional plane at points to be avoided.

The heart of the method is an algorithm that examines the slope of surface S . The objective is to determine which way to move in n -dimensional space to go "uphill" on S to the precise datum sought. In the example at the top of the figure, the slope is uphill from the point (0,0) to the point (0,1). Thus, the approximate query (0,0) would produce the exact response (0,1).

If the query conflicts sufficiently with all stored data or is ambiguous, the system responds with an appropriate indication. For example, as shown at the bottom of the figure, the query (1,0) or (0,1) would produce the responses (0,0) and (1,1) with an

indication that either response is equally likely to be correct. In a more realistic problem with a greater number of dimensions and stored data, the user might help resolve the ambiguity by refining the query or modifying the stored data.

This work was done by Lui Wang of Johnson Space Center and Gordon G. Johnson of Barrios. For further information, Circle 39 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 22]. Refer to MSC-21415.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Monograph on Tensor Notations

Indicial tensor, vector, dyadic, and matrix notations, and the relationships among them are described.

An eight-page report describes the systems of notation that are used most commonly to represent tensors of various ranks, with emphasis on tensors in Cartesian coordinate systems. The report could serve as an introductory or refresher text for scientists, engineers, and others who are familiar with the basic concepts of coordinate systems, vectors, and partial derivatives.

One major section of the report describes the indicial or tensor notation, in which each subscript or superscript denotes a projection onto a coordinate axis and the number of subscripts and superscripts denotes the rank. Vectors are identified as first-rank tensors, and dyadics are identified as second-rank tensors. Covariant and contravariant vector transformations are defined and identified as tensors of second rank. The Kronecker delta (the identity dyadic) and the permutation tensor (in three dimensions) are presented as important special tensors. The inner (dot) and vector (cross) products of vectors are defined. The use of the indicial notation to determine relationships among sums and products of tensors is illustrated by use of an example.

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The next major section of the report describes the vector and dyadic notations, in which each vector, dyad (direct product of two vectors), or dyadic (sum of dyads) is represented without subscripts or superscripts that refer to particular coordinate axes. The effects of dot and cross products are discussed. The concept is extended to triadic notation, illustrated by an example of the use of the permutation tensor in three dimensions as a third-order triad. In another example, the partial derivative, with respect to the second vector, of a cross product of two vectors is represented as a dyadic.

The third major section describes matrix notation, which offers a coordinate-de-

pendent representation of vectors or dyadics, with a simple link to the coordinate-free representation. Dot and cross products are described. It is explained how matrix notation makes it relatively easy to determine transformations of vectors and dyadics.

Other notations are mentioned but not discussed in detail. These include quaternion notation (useful in characterizing rotations) and matrix notations in spaces of more than two dimensions.

This work was done by Samuel W. Sirlin of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Notations for Tensor Manipulation," Circle 104 on the TSP Request Card. NPO-18250

Vision Science and Technology at NASA

NASA scientists and engineers describe their work and plan future research and development.

A report presents the results of a workshop-type conference on vision science and technology (VST) at the National Aeronautics and Space Administration. About 50 NASA scientists and engineers participated in the workshop with the following goals:

- Refining the definition of VST,
- Identifying NASA's VST needs,
- Taking inventory of NASA's expertise in relevant disciplines,
- Fostering communication among NASA groups, and
- Developing a strategy for further work on VST.

Through VST, researchers seek to understand vision in humans and machines at the biological, physical, and mathematical levels and to translate their findings into practical advances in human factors, displays, image processing, and autonomous robotic vision.

The report describes the VST needs of wide-ranging NASA projects, including a planetary rover, automatic rendezvous and docking, study of global change, and a hypersonic civilian transport aircraft. It summarizes the VST activities and lists the principal researchers at NASA research centers. It analyzes the strengths and weaknesses of NASA VST programs. It proposes specific strategies for building an effective VST program for the future. The report includes a compilation of abstracts of papers presented at the workshop.

The report concludes that, although NASA work on VST is of high quality, the level of effort is insufficient to meet the demands of future missions. It recommends that the NASA program on VST be strengthened by explicitly acknowledging VST in planning and funding, adding to the VST research staff, encouraging specialization in research on selected topics, establishing a center of excellence in VST, promoting collaboration with universities and among NASA centers, and adopting a long-term emphasis on fundamental work in VST to support future applications.

This work was done A. B. Watson and J. B. Mulligan of Ames Research Center. Further information may be found in NASA TM-102214 (Revision 1) [N90-22216], "Vision Science and Technology at NASA: Results of a Workshop."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-13116



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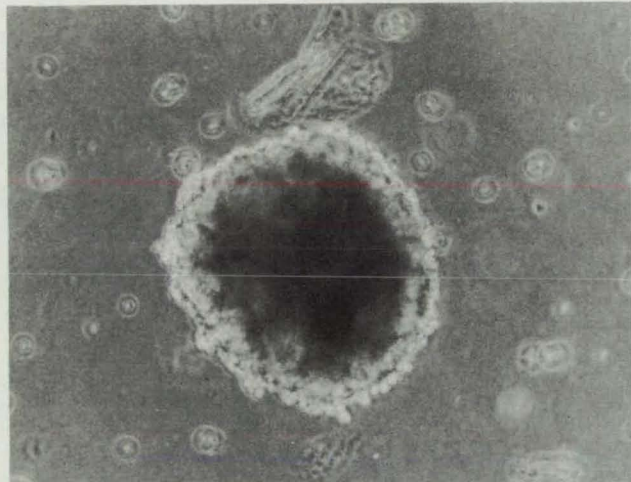
Life Sciences

In Vitro, Matrix-Free Formation of Solid Tumor Spheroids

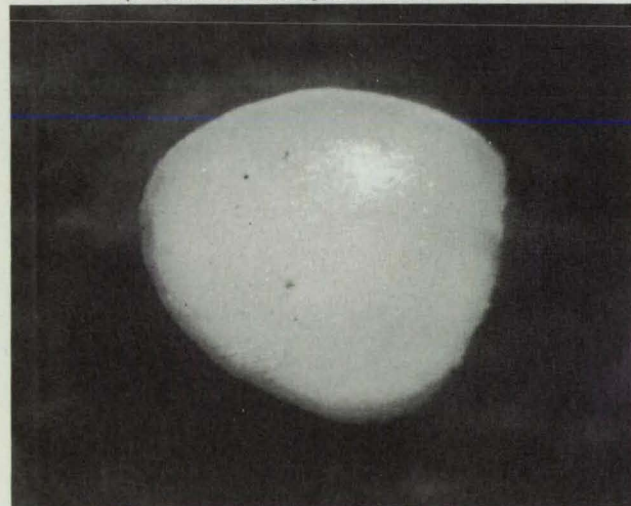
Spheroids develop from anchorage-dependent and suspension cells in a bioreactor.

*Lyndon B. Johnson Space Center,
Houston, Texas*

An in vitro matrix-free process forms relatively large solid tumor spheroids from suspension cells and from anchorage-dependent cells in a clinostatic bioreactor developed by NASA. The reactor vessel rotates slowly about a horizontal axis and is configured so that the rotation gives rise to an approximation of zero-gravity growth conditions. The reactor promotes the formation of relatively large spheroids by maintaining low shear forces while supplying adequate nutrients and removing wastes. Tumor spheroids cultured in this way have exhibited diameters from 750 to 2,100 μm ; these spheroids have been closer, in size and mass, to theoretical avascular in vivo tumors than were cultured by use of older techniques. The process may be useful in studying the efficacy of chemotherapeutic agents against tumor cell masses and in the study of in-

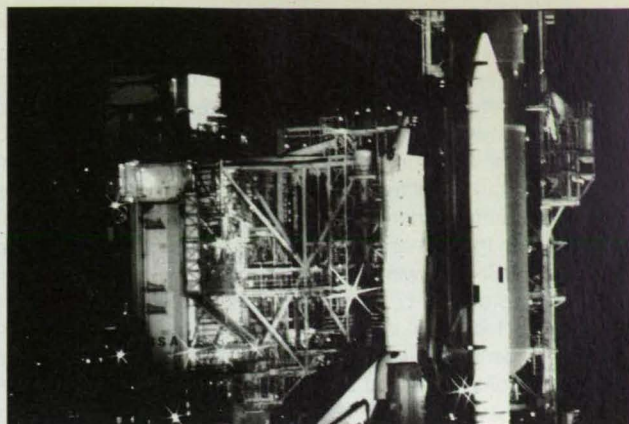


Spheroid From Small-Cell Lung-Cancer Cell Line NCI-H146



Spheroid From Human Glioma Cell Line HBr09

These **Spherical Clumps of Cancer Cells** were grown by use of the process described in the text.



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teractions between cells that are not constrained by solid matrices.

Two versions of the process have been demonstrated: one for anchorage-independent cells and one for anchorage-dependent cells. In preparation for the demonstrations of the version for the anchorage-independent cells, suspension cells from the human small-cell lung cancer line NCI-H146 were cultured as follows: A large-bore glass pipette was used to resuspend 1.25×10^7 log-phase anchorage-independent cells in 50 mL of fresh nutrient medium that had a temperature of 37 °C. A reactor of 50-mL capacity was filled with this inoculated medium, and a 20-mL syringe filled with fresh medium was attached to the reactor, which was then attached to a spindle shaft in a 5-percent-CO₂ incubator with a 0.2-µm air-filtration pump. A 25-rpm rotation was begun immediately, increased to 30 rpm at

24 h, and increased to 35 rpm at 48 h. Every second day, 20 mL of fresh medium prewarmed to 37 °C was inoculated, the pH was maintained at 7.3, and the concentration of glucose was maintained at 175 mg/dL. The process was maintained for 8 to 10 days for optimal growth and development of spheroids. The upper part of the figure shows a spheroid that developed in 8 days.

In preparation for the demonstrations of the other version of the process, anchorage-dependent cells from the human glioma cell line HBr09 were cultured as follows: Cells from monolayer cultures were trypsinized, centrifuged, and resuspended in fresh medium at 37 °C. The reactor was filled with this medium, and a 20-mL syringe filled with fresh medium was attached. The reactor was then attached to the spindle shaft and placed in the incubator, where it was held for 2 h without

rotation. After 2 h, the vessel was made to start rotating at 12 rpm. The rate of rotation was increased to 22 rpm at 4 h, to 30 rpm at 6 h, and to 41 rpm at 26 h. Daily, 20 mL of fresh medium prewarmed to 37 °C was inoculated, the pH was maintained at 7.3, and the concentration of glucose was maintained at 280 mg/dL. The process was maintained for 6 to 8 days. The lower part of the figure shows a spheroid that developed in 8 days.

This work was done by Steve R. Gonda and Garry M. Marley of **Johnson Space Center**. For further information, Circle 20 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 22]. Refer to MSC-21843.

Prosthetic Hand With Two Gripping Fingers

Rotation of the remaining part of the forearm controls one of the fingers.

Marshall Space Flight Center, Alabama

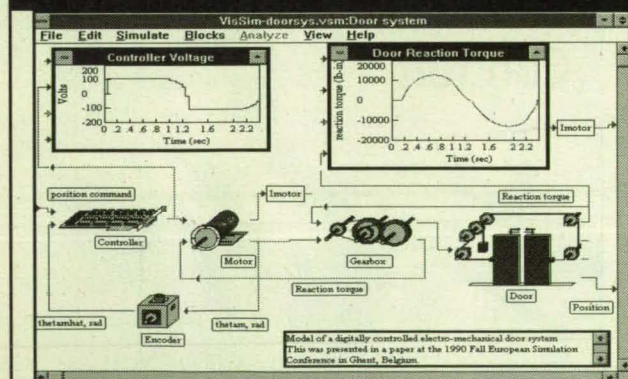
The figure illustrates a prosthetic hand for an amputee who retains a significant portion of a forearm. The outer end of the device is an end effector that includes two fingers, one of which can be moved by

rotating the remaining part of the forearm about its longitudinal axis.

The prosthetic hand is fitted to the upper arm by means of a flexible upper cuff, which is held in place by hook-and-pile

strips (Velcro® or equivalent). A tubular lower cuff surrounds the upper part of the remaining forearm without pressing on it or restricting its movement. The flexible upper cuff and the tubular lower cuff are

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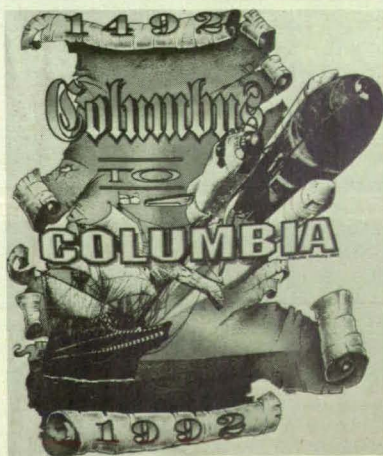


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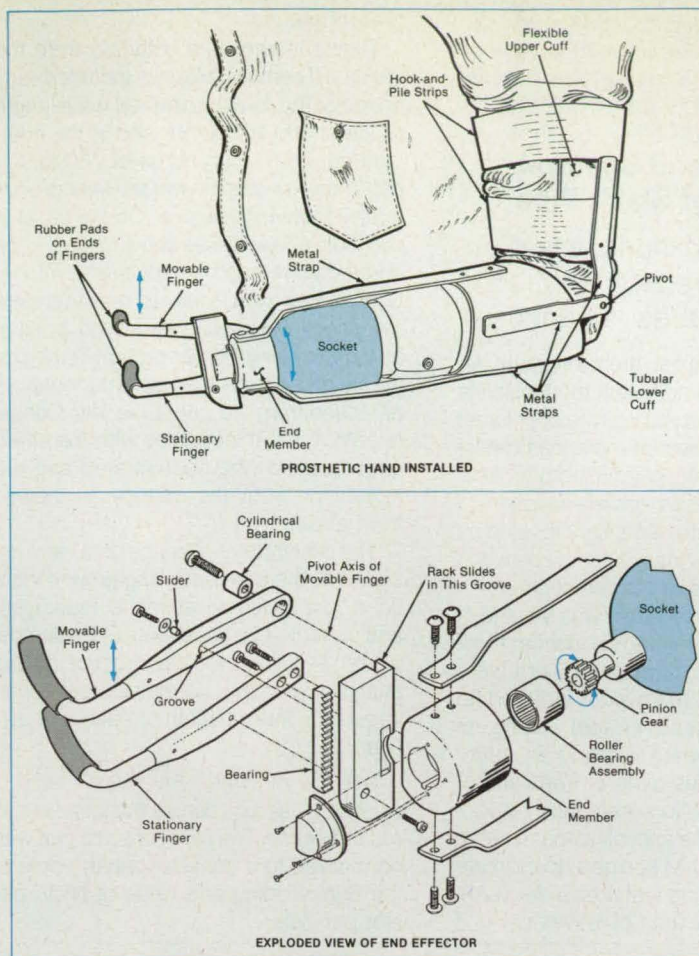
joined by metal straps that pivot about the axis of the elbow joint.

The main body of the end effector is an end member that supports the fingers, a roller bearing assembly, and a rack-and-pinion mechanism that moves the upper finger. A socket and a pinion gear are joined by a shaft that turns in the roller bearing assembly. Two metal straps secure the end member to the tubular lower cuff. The lower finger is fixed on the end member. The upper finger pivots about a cylindrical bearing on the end member, and a slider attached to the rack fits in a groove in the upper finger.

The remaining part of the forearm fits snugly in the socket. The rotation of the forearm and socket drives the pinion gear, which in turn drives the rack up or down. The mechanical advantage of the rack-and-pinion mechanism enables the user to open or close the gap between the fingers with considerable precision and force.

This work was done by William E. Norton, Jewell B. Belcher, Thomas W. Vest, and James R. Carden of **Marshall Space Flight Center**. For further information, Circle 28 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28627.



Rotation of the Remaining Part of the Forearm about its longitudinal axis drives the rotation of the socket, which is part of the mechanism that moves the upper finger.



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Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Leaf Areas and Spectral Properties of Slash Pine

Seasonal variations in leaf area are correlated with red and near-infrared radiances.

A NASA technical memorandum describes experiments to test the feasibility of estimating seasonal leaf areas of forest canopies from spectral radiances measured by remote (e.g., satellite-borne) instruments. Accurate estimates of seasonal leaf areas of forests are necessary for studies of seasonal exchanges of energy between forest canopies and the atmosphere.

The experimental forest was a stand of slash pine (*Pinus elliotii*) in northern Florida. Sixteen plots, each 50 x 50 m were used, and half of them were fertilized (to stimulate increases in foliage). During approximately 3 years starting in 1986, samples of various parts of trees and of litter on the forest floor were taken at various intervals (some annual, some monthly, some twice monthly) and used to estimate the monthly varying leaf area index (LAI), which is the total area of leaves per unit

area of ground.

Digital image data obtained from the Landsat Thematic Mapper included radiances of the forest in the red wavelength range of 630 to 690 nm and in the near-infrared wavelength range of 760 to 900 nm. These wavelength ranges were chosen for the following reasons: On the basis of previous studies, it was known that at near-infrared wavelengths, radiation is strongly scattered within leaves and therefore reflection from the canopy is high, but that at red wavelengths, absorption in the pigments of the leaves is high and therefore reflection from the canopy is low. Consequently, the LAI increases with the difference between the near-infrared and red reflections from the canopy as viewed from above.

The digital spectral image data were assigned to the corresponding ground locations, converted to absolute radiances, and corrected for the effects of the atmosphere. The intermediate product of this analysis was the normalized-difference vegetation index (NDVI) of each plot, defined by

$$NDVI = (L_{NIR} - L_R) / (L_{NIR} + L_R)$$

where L_{NIR} and L_R denote the infrared and red radiances. The NDVI of each plot was normalized to a constant zenith angle of the Sun, yielding one value of NDVI per plot per date.

Linear relationships between the values of NDVI and LAI with correlation coefficients of 0.35, 0.75, and 0.86 were found in the data from all 16 plots taken in February 1988, September 1988, and March 1989, respectively. Then linear relationships were derived from data pertaining to eight of the plots and used to estimate the LAI of each of the other eight plots from its normalized NDVI. The root-mean-square error of these estimates of LAI was 0.74, which was only 15.6 percent of the average of the LAI values obtained from the ground samples. Thus, it appears that there may be potential for the use of remote sensing in estimating seasonal changes in LAI.

This work was done by Paul J. Curran of the University College of Swansea, Jennifer L. Dungan of TGS Technology, and Henry L. Gholz of the University of Florida for Ames Research Center. Further information may be found in NASA TM-102278 [N90-25397], "Seasonal LAI in Slash Pine Estimated With Landsat TM."

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

ARC-12857

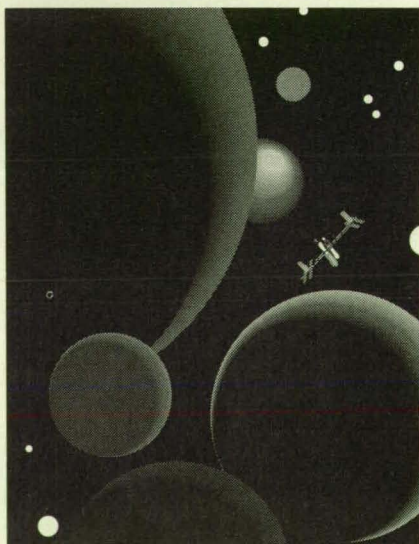


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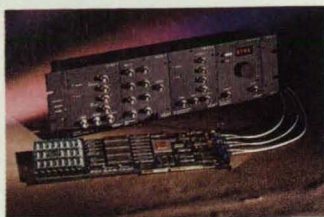
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New on the Market

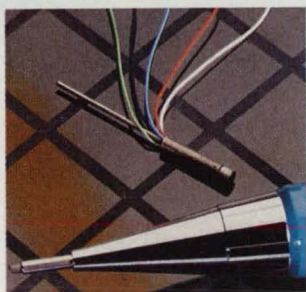
Advanced Micro Systems Inc., Nashua, NH, has unveiled a general-purpose **computer** that eliminates the need for large PCs in an industrial environment, according to the manufacturer. Used as a primary process or slave controller, the new BIB-52 features up to 128 KB battery-backed memory, 72 filtered inputs, 72 high-powered outputs, RS-232/RS-485 Party Line communications, and a customized Intel BASIC interpreter with floating point math. **For More Information Circle No. 768**



The AP2 **array processor card** announced by Tucker-Davis Technologies, Gainesville, FL, provides scientists and researchers with a sophisticated and integrated platform for AT bus machines, significantly reducing software development and laboratory set-up time. It features a high-speed, noiseless fiber-optic link to over 30 modular signal processing components. Employing AT&T's DSP32C floating-point processor, the AP2 runs at 50 MHz for a peak performance of 25 MFLOPS. **For More Information Circle No. 764**



Nylok Fastener Corp., Rochester, MI, has developed a locking device and process that provides threaded **fasteners** with consistent self-locking ability at temperatures up to 232° C. NYTEMP™ fasteners meet the torque and vibration requirements of MIL-F-18240E as well as IFI-124 and IFI-524 specifications. Made of a highly temperature-resistant polymer, the locking element is applied as an orange-colored patch to internally or externally threaded parts and can be varied to suit particular torque requirements. **For More Information Circle No. 766**



The EPI-050 **pressure sensors** from Entran Devices Inc., Fairfield, NJ, feature a micro-miniature size, broad measuring range, and static and high-frequency capability. The sensors are so small that they can approximate a true point measurement, according to the manufacturer. They employ a 0.05" diameter silicon chip sensing element, with three standard mounting configurations. Probes are available to measure pressures from 1-2 psi and 0-300 psi with outputs as high as 125 mV and resonant frequencies to 1.7 MHz. **For More Information Circle No. 772**



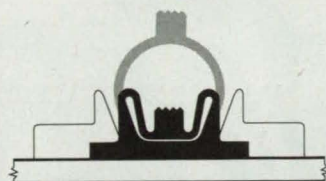
CupraSelect™, a novel **copper compound for processing semiconductor devices**, has been formulated by Schumacher, Carlsbad, CA. The high electrical conductivity of copper will make it a key component in future ultracompact, high-speed microchips, according to the manufacturer, replacing aluminum as the material of choice. CupraSelect, a volatile liquid copper compound designed for chemical vapor deposition of copper films, enables thin-film technology to be used widely in integrated circuit manufacturing, multichip module fabrication, and flat panel display wiring. **For More Information Circle No. 788**

Pacific Cyber/Metrix Inc., Dublin, CA, has integrated multiple DSP processors and video acquisition hardware to permit **real-time image processing** with sophisticated software-driven algorithms. The new board-level VMEbus system, called DSP-38, can extract information embedded in images acquired from visible-light cameras, tomographic equipment, radar, sonar, and infrared systems. Computers learn how to "see," making it practical to build systems such as autonomous vehicle controllers, object trackers, and robots that can act on image stimuli. **For More Information Circle No. 770**

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For More Information Circle No. 516

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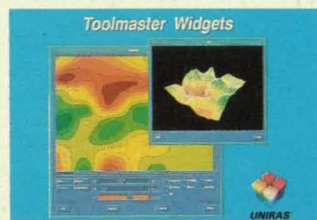
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For More Information Circle No. 568

New on the Market

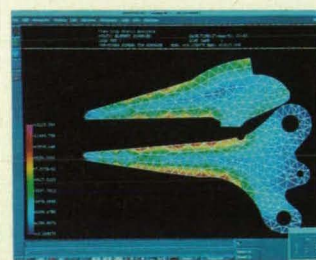
UNIRAS Inc., Dallas, TX, is offering an update of its Toolmaster **scientific visualization software** designed to significantly reduce the programming effort necessary for graphics-based visualization applications. Available for UNIX workstation and supercomputer platforms, the new version features an integrated GUI-builder that allows the user to develop and test a graphical user interface and graphics application code simultaneously as well as a family of custom widgets that perform pre-defined visualization operations and include ready-to-use interface components such as color selectors.

For More Information Circle No. 784



Applicon Inc., Ann Arbor, MI, has introduced Bravo Version 4.0, easy-to-use **engineering tools for design and manufacturing**. The software marks the commercial debut of the company's Dynamic Modeling™ technology which, unlike parametric and variational modeling methods, uses geometric principles directly. Dynamic Modeling allows users to capture their design intentions, modify the geometric relationships that express those intentions, and evaluate multiple design alternatives—all in real time.

For More Information Circle No. 778



Shimadzu Scientific Instruments Inc., Columbia, MD, has introduced **thermal analysis software** that combines multi-tasking features to enable real-time data collection and analysis on up to four instruments simultaneously. Called TA-50WS, the software runs under Windows 3.1. It automatically defaults, codes, and saves each file by date, time, and channel, and provides resident ASCII conversion for easy importing and exporting of data.

For More Information Circle No. 786



CENTRIC Engineering Systems Inc., Palo Alto, CA, has announced Spectrum™, the first **simulation-based design program** to incorporate multiphysics, intelligent numerical algorithms, and scalable processing capabilities. The software's full spectrum physics capabilities permit engineers to simulate comprehensively a product's behavior during the design process, resulting in better designs, lower design costs, and reduced time to market. Spectrum is available for workstation, departmental, and high-performance computer environments.

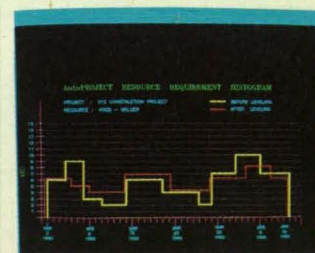
For More Information Circle No. 776

The industry's smallest and lightest **400 VA battery backup (UPS) system** has been announced by Tripp Lite, Chicago, IL. Dubbed the BC 400, the unit incorporates redesigned circuitry for high-performance powering of desktop PCs, phone systems, cash registers, or internet hardware such as hubs, bridges, and routers. The BC 400 features two spike-protected AC outlets, large batteries for longer life, and a highly efficient pulse-width-modulated waveform output.

For More Information Circle No. 780

AutoPROJECT, integrated **project management software** that runs in the AutoCAD environment, has been released by Research Engineers Inc., Orange, CA. Features include various means of data entry—graphical, form screens and command file or batch mode; multiple calendars; algorithms to allow automatic activity split, multiple resource leveling, resource-constrained time scheduling, and earned value analysis; cost-performance S curves; and a custom report generator for individual and comparison reports.

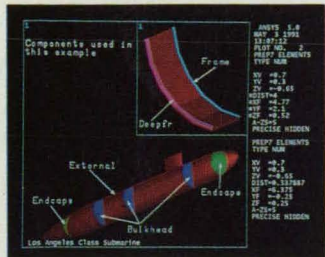
For More Information Circle No. 782



NASA Tech Briefs, March 1993

New on the Market

Swanson Analysis Systems Inc., Houston, PA, has released revision 5.0 of its **ANSYS finite element analysis software**. The program contains enhancements to nonlinearities, solid modeling, solid meshing, graphics, magnetics, design optimization, and the user interface. ANSYS is integrated with the FLOTRAN® computational fluid dynamics program to offer a common user interface for model building and analysis. **For More Information Circle No. 794**



The 3054 DSP System from Tektronix Inc., Beaverton, OR, offers the fastest available **real-time spectrum analysis**. The 3054 uses a unique bank-of-filters analyzer and newly-designed processing to provide spectral frame update rates as fast as 12.5 μ S. Updated memory processing and data compression methods expand stored capture time coverage to a range of 0.8 seconds to more than 26,000 seconds. **For More Information Circle No. 800**



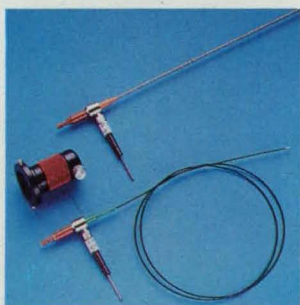
Star Semiconductor Corp., Warren, NJ, has introduced the first **signal processor** to run at a sustained rate of 40 MIPS. The SPROC-1400 employs four 50 MHz general signal processors running concurrently on a single chip to deliver a combined instruction cycle time of 25 nanoseconds. Utilizing a 0.8-micron manufacturing process, Star reduced the size and cost of the SPROC-1400 chip, which can replace multiple first-generation digital signal processors and hundreds of analog components with an easy to program, integrated solution. **For More Information Circle No. 798**



The ADPI™ One For All™ **tape backup system** from Analog & Digital Peripherals Inc., Troy, OH, can support multiple PCs in an office. It plugs directly into the parallel printer port of a computer without the use of controller cards or special adapters. Available in 160/320 or 600/1200 MB versions, the system provides up to 12 MB per minute backup, set-up time of one minute or less, and a menu-driven IBM SAA/CUA interface. **For More Information Circle No. 792**

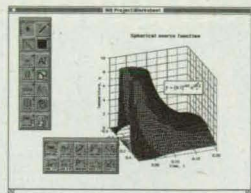
Universal Technical Systems Inc., Rockford, IL, has introduced Dynamics and Vibrations Analysis (DVA), **software designed to dramatically reduce the time required to analyze the vibration of structures and fluids**. DVA solves problems with forward and backward analysis and produces plots of mode shape with a simple menu selection. It covers a variety of topics including geometric properties of plane areas and solid bodies; spring and pendulum systems; straight beams, curved beams, and frames; cables and cable trusses; and plates, membranes, and shells. **For More Information Circle No. 760**

A small-diameter modular **bore-scope** from Machida Inc., Orangeburg, NY, enables internal visual inspection of hard to reach areas. The system is comprised of three main detachable elements—an eyepiece ocular, a light guide cable, and a flexible or semi-flexible probe. Probes with diameters ranging from .025" to .079" and working lengths of 11" or 23" are available. **For More Information Circle No. 796**



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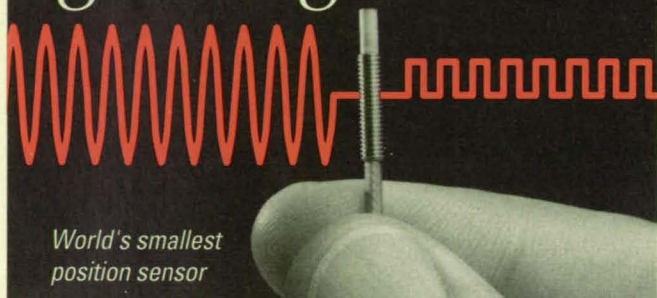


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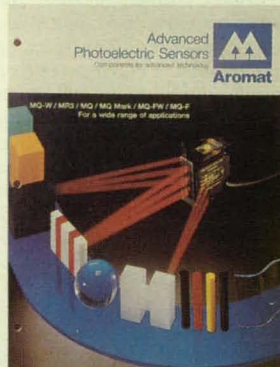
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New Literature

Aromat Corp., New Providence, NJ, has published a guide to **advanced photoelectric sensors** for OEM designers and production engineers. The 44-page guide features the company's Triple Beam™ photoelectric, mark, and fiber-optic sensors, which can detect targets of any color for use in difficult counting, detection, and range-verification applications. Also covered are sensor specifications, performance features, and installation instructions.

For More Information Circle No. 706

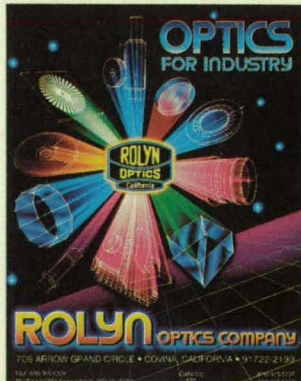


A 220-page handbook on **low-level measurements** is offered by Keithley Instruments Inc., Cleveland, OH. The updated handbook covers essential techniques for improving measurement accuracy including sections on common low-level voltage, current, and resistance measurement techniques, typical applications, error sources and how to avoid them, and an instrument selector guide. Intended for both measurement experts and novices, the guide includes a detailed glossary.

For More Information Circle No. 704

A 130-page **optics** catalog has been released by Rolyn Optics Co., Covina, CA. Product categories include simple and compound lenses, prisms, optical slats/flat glass, flat and concave mirrors, absorption and thin-film filters, beamsplitters, reticles, and instruments. The firm also provides custom cutting, coating, edging, and fabrication services.

For More Information Circle No. 712

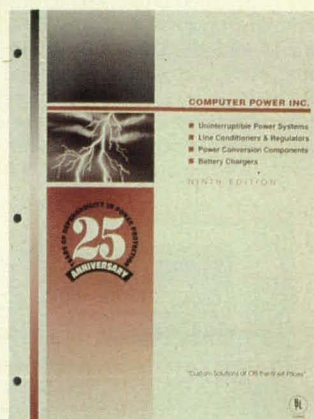


Balzers High Vacuum Products, Hudson, NH, has released a catalog describing its **components for vacuum production, measurement, and control**. They include rotary vane and roots vacuum pumps, turbo-molecular and diffusion pumps, UHV technology, total pressure gauges and control units, leak detectors, and quadrupole mass spectrometers. The 228-page catalog provides data on product performance, applications, technical specifications, and accessories.

For More Information Circle No. 708

A reference catalog of **standby and on-line static UPS, line conditioners, battery chargers, and OEM power conversion components** has been published by Computer Power Inc., High Bridge, NJ. Featured are 100VA single-phase to 100kVA three-phase models with ferroresonant and PWM technology designed for harsh environments. The products are suited for critical applications in industrial plants, computer installations, communications centers, and electrical facilities.

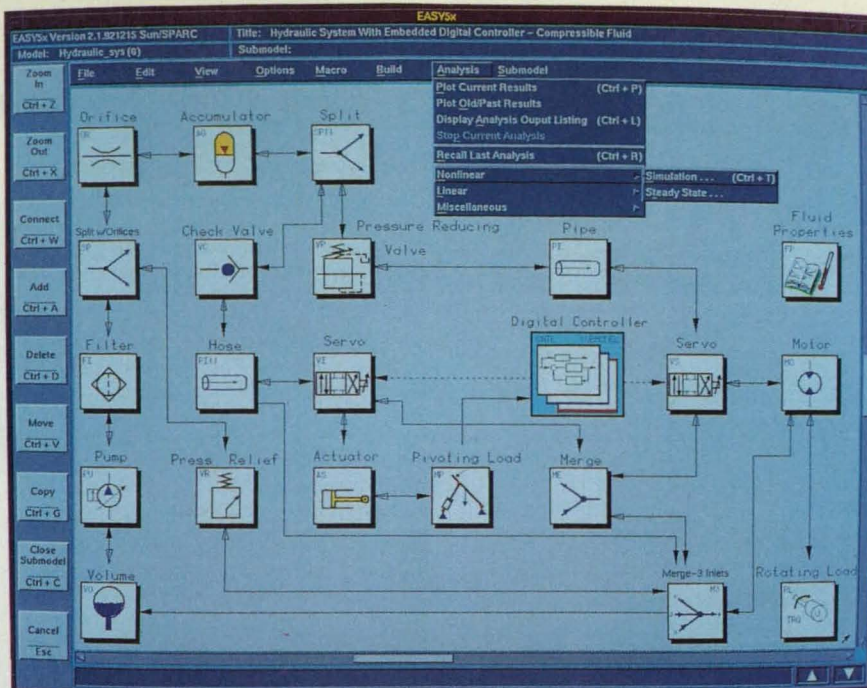
For More Information Circle No. 720



OMEGA Engineering Inc., Stamford, CT, has announced its **1993 Data Acquisition & Control Buyer's Guide™**. The publication highlights a wide variety of plug-in boards, software, counters, timers, converters, PC instrumentation, communications equipment, motion controllers, and signal conditioners.

For More Information Circle No. 702





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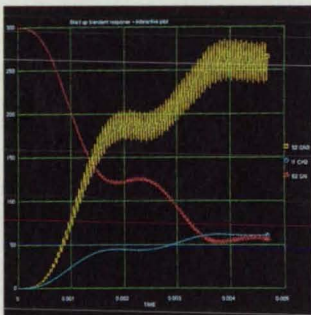
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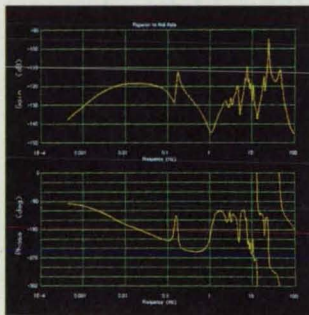
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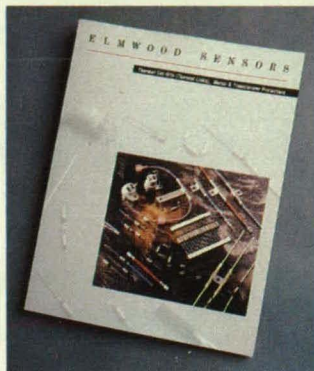
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New Literature

Elmwood Sensors Inc., Pawtucket, RI, has released a product guide highlighting its **thermal cut-offs (TCOs) and motor and transformer protectors (MTPs)**. The thermal fuses offer design engineers cost-effective alternatives for a wide variety of thermal protection applications. Featured products include the RD-Series TCOs, which are configured for use in HVAC applications and available in ceramic teardrop and round base styles.

For More Information Circle No. 718



American Variseal, Broomfield, CO, has announced its new selection guide for high-performance **spring-energized seals**. The color manual details a wide range of products for static, reciprocating, and rotary service with data on seal materials, gland design, and surface finish.

For More Information Circle No. 714

A **pressure transducer and pressure transmitter** brochure has been published by Taber Industries, North Tonawanda, NY. Transducers are available in low-level and high-level models in a variety of pressure ranges. They offer infinite resolution, repeatability within 0.10% FSO, and compensated temperature range from -30° to 170°F . Taber's differential transducer series provides high differential overload pressure and high line pressure as well as repeatability within 0.2% FSO.

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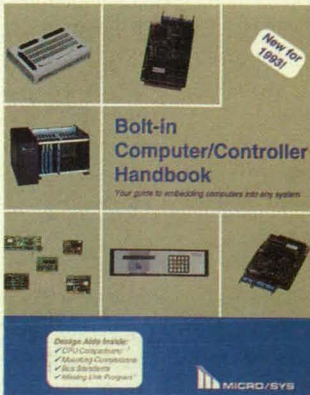


A brochure from Shin-Etsu Silicones of America Inc., Torrance, CA, showcases one- and two-component **RTV silicones**. It details applications, advantages and disadvantages, storage and handling, bonding, curing, and dispensing. A physical component chart for one-component silicones explains the multiple cure systems and primers available, while the two-component chart addresses primers and catalysts.

For More Information Circle No. 710

A **bolt-in computer/controller handbook** from Micro/sys Inc., Glendale, CA describes more than 200 products for embedding computers and controllers and provides guides on CPU selection and mounting. Featured are computer boards from 8051s to 486s, as small as $3'' \times 4''$; cardrack-based computer and I/O boards; and 19" rack computers with LCD displays and keypads.

For More Information Circle No. 716



Compumotor and Digiplan, divisions of Parker Hannifin Corp., Rohnert Park, CA, have jointly published a **positioning control systems and drives catalog**. It provides information on DC brush and AC brushless servo systems, full step and microstepping systems, linear step motor systems, microprocessor-based indexers, and incremental and absolute encoders. New Compumotor products include the AT6400 four-axis indexer, the model 6200 two-axis indexer, and the OEM650 series of OEM-oriented microstepping systems.

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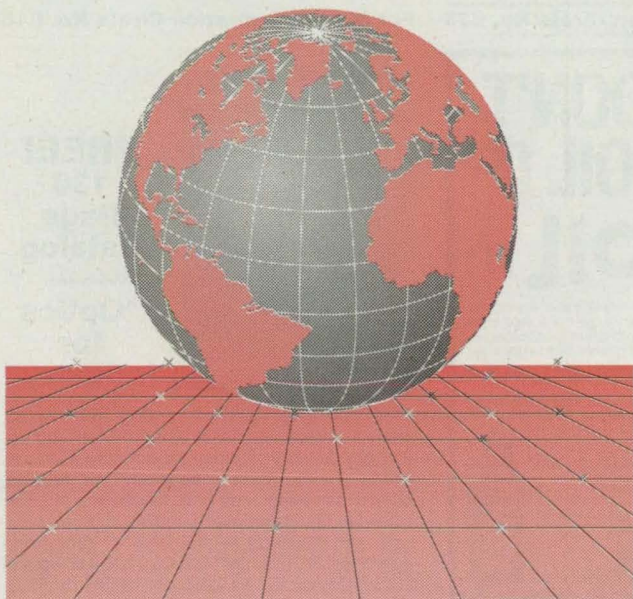
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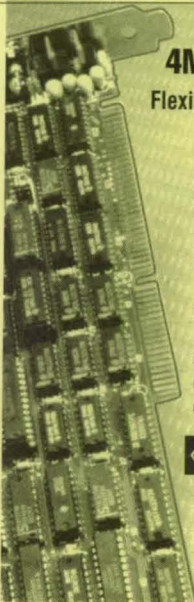


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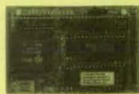


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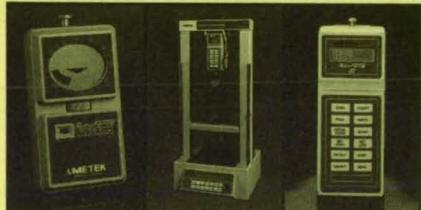
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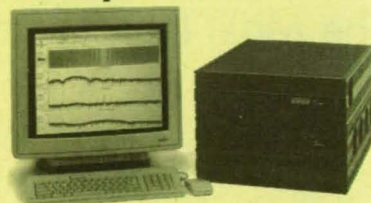
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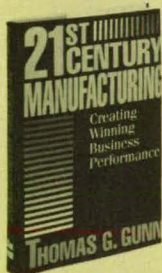
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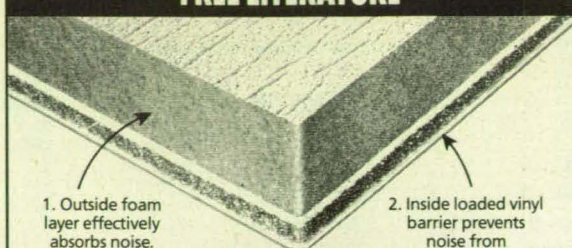
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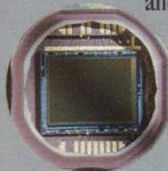
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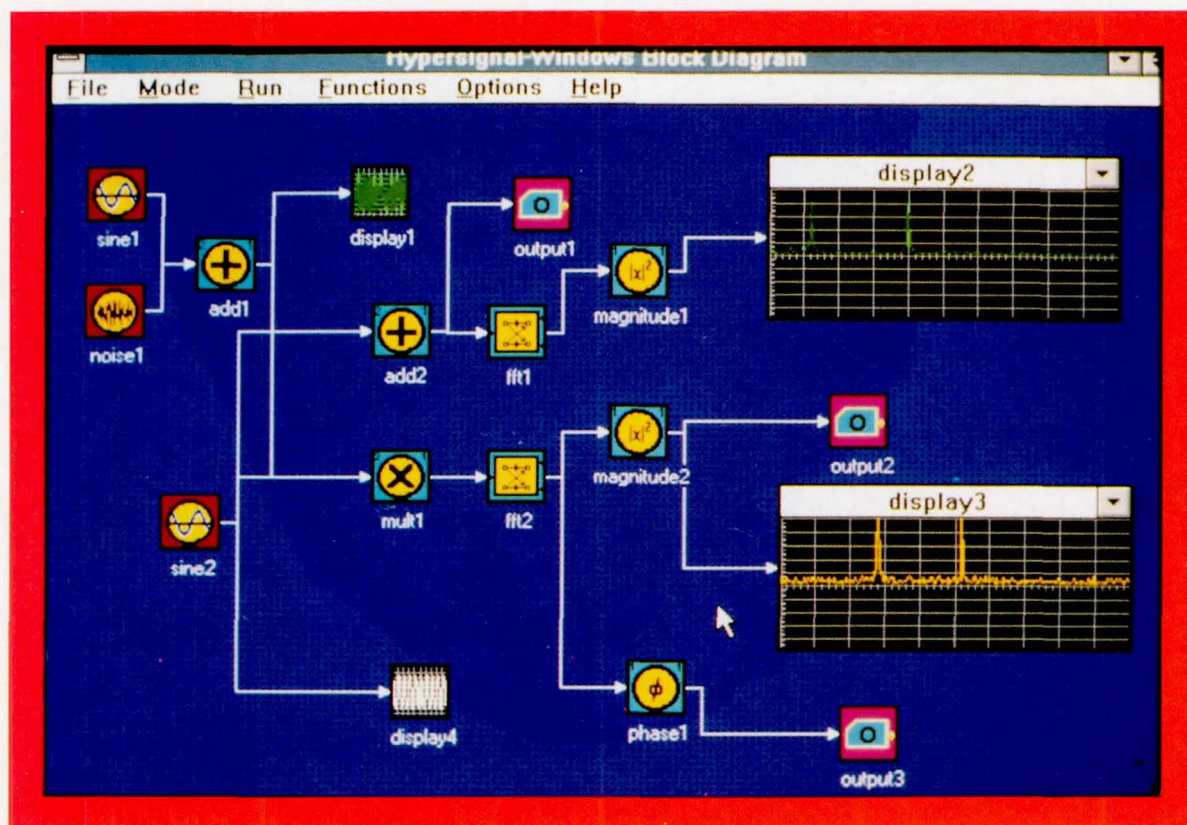
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